

KEPCO
POWER SUPPLIES

KEPCO, INC. • 131-38 SANFORD AVENUE • FLUSHING, N.Y. 11352 • Phone: (212) 461-7000

DESIGN GROUP FEATURES CHART

	ABC TRANSISTORIZED	ABC HYBRID	BHK	CDT	CK	CK-HS	HB	KG	KO	KS	OPS	OPS-TA	PAR	PAT	PAX	PBX	PBX-MAT	PR	PRM	PWR	SM	WR
DC Voltage Regulation	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Adjustable Output	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*		*	*	*
Narrow Range Adjustment (slot)													*							*		
Built-in Output Controls	*	*	*	*	*	*	*	*	*	*		*	*				*	*		*	*	*
Remote Control Capabilities	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*			*		
Operationally Programmable	*	*	*	*	*	*	*	*		*	*	*		*	*	*	*					
Amplifier Common Positive		*	*	*			*	*			*	*		*		*	*					
Amplifier Common Negative	*				*	*			*	*					*							
Solid State Design	*			*	*	*		*	*	*	*	*	*	*	*	*	*	*	*	*	*	
Hybrid (Tube-Transistor) Design		*	*				*				•											
Vacuum Tube Design																						*
Silicon Controlled Rectifiers									*	*												
Resonant Power Transformer (Flux-O-Tran)®																		*	*	*	*	
Current Limiting	*	*		*				*			*	*		*	*	*	*	*	*			
Current Cutoff													*							*		
Automatic Crossover Current Regulator			*		*	*			*	*	•											
Current Regulating with External Sensor	*	*	*	*	*	*	*	*		*	*	*	*	*	*	*	*			*		
VIX® Crossover Mode Indicators			*		*	*				*												
Resonant Input, Single Frequency (50 or 60 cps.)																		*	*	*	*	
Input Frequency Range 50-65 cps.					*	*		*	*	*	•											•
Input Frequency Range 50-440 cps.	*	*	*	*			*				•	*	*	*	*	*	*					•
Cooling by Convection	*	*	*	*			*	*			*	*	*	*	*	*	*		*	*		*
Cooling by Forced Air					*	*			*	*								*			*	
Laboratory Bench-Style Package	*	*	*	*	*	*	*		*	*	•	*					*	*			*	*
Modular Style for Chassis or Rack											*		*	*	*	*			*	*		
Plug-in Style Modules								*			*	*	*		*	*	*		•	*		
Rack Mountable	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Meters	*	*	*	*	*	*	*		*	*							*	*			*	*

This chart lists, briefly, the salient features and characteristics of the many different Kepco design groups. In general each model within a group shares the characteristics of its group and may be identified by its outstanding features.

* All models
• Some models



KEPCO POWER SUPPLIES

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INDEX BY OUTPUT VOLTAGE

This index is specially arranged to facilitate the selection of the proper power supply for every job. It complements the *design group* listings by grouping models according to their *voltage rating*. Thus, for example, it is easy to determine which *groups* have models in any desired *voltage range* – and then to examine their comparative specifications in detail.

DC OUTPUT VOLTS	DC OUTPUT AMPS	MODEL	PAGE
0–2	0–1	ABC 2–1M	6
0–2	0–8	CK 2–8M	10
4±5%	0–11	PAR–4	17
4±5%	0–14	PWR 4–14	23
Dual 4.5	0–20	PRM 2X4.5–20	24-25
6.3	0–15	PRM 6–15	24-25
Dual 6.3	0–20	PRM 2X6–20	24-25
6.3	0–25	PRM 6–25	24-25
6.3	0–25	PRM 6–25F	24-25
0–7	0–1	PAX 7–1	19
0–7	0–2	PAT 7–2	18
0–7	0–2	OPS 7–2	16
0–7	0–2	OPS 7–2TA	21
0–7	0–2	PBX 7–2	20
0–7	0–2	PBX 7–2MAT	21
7±5%	0–10	PAR–7	17
7±5%	0–11	PWR 7–11	23
0–7.5	0–2	ABC 7.5–2M	6
0–8	0–5	CK 8–5M	10
0–8	0–5	CK8–5MHS	11
0–8	0–15	KS 8–15M	15
0–8	0–25	KS 8–25M	15
0–8	0–50	KS 8–50M	15
0–8	0–100	KS 8–100M	15
0–10	0–0.75	ABC 10–0.75M	6
0–12	0–100	KO 12–100M	14
12±5%	0–7	PAR–12	17
12±5%	0–7	PWR 12–7	23
12	0–10	PRM 12–10	24-25
Dual 12	0–12	PRM 2X12–12	24-25
12	0–15	PRM 12–15	24-25
12	0–15	PRM 12–15F	24-25
0–14	0–7	SM 14–7AM	26
0–14	0–15	SM 14–15AM	26
0–14	0–30	SM 14–30AM	26
0–15	0–0.75	PAX 15–0.75	19
0–15	0–1	ABC 15–1M	6
0–±15	0–±1.5	CDT 15–1.5M	9
0–15	0–1.5	OPS 15–1.5	16
0–15	0–1.5	OPS 15–1.5TA	21
0–15	0–1.5	PAT 15–1.5	18
0–15	0–1.5	PBX 15–1.5	20
0–15	0–1.5	PBX 15–1.5MAT	21
15±5%	0–6	PAR–15	17
15±5%	0–6	PWR 15–6	23
0–7.5–15	0–10	PR 15–10M	22
0–15	0–30	PR 15–30M	22
Dual 15	0–10	PRM 2X15–10	24-25
0–18	0–0.5	ABC 18–0.5M	6
0–18	0–3	CK 18–3M	10

each model within a group shares the characteristics

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DC OUTPUT VOLTS	DC OUTPUT AMPS	MODEL	PAGE
0–18	0–3	CK 18–3MHS	11
0–18	0–10	KS 18–10M	15
0–18	0–15	KS 18–15M	15
0–18	0–25	KS 18–25M	15
0–18	0–50	KS 18–50M	15
18	0–6.7	PRM 18–6.7	24-25
Dual 18	0–8	PRM 2X18–8	24-25
18	0–10	PRM 18–10	24-25
18	0–10	PRM 18–10F	24-25
0–20	0–0.05	OPS–1A	16
0–20	0–100	PR 20–100AM	22
0–21	0–0.5	PAX 21–0.5	19
0–21	0–1	OPS 21–1	16
0–21	0–1	OPS 21–1TA	21
0–21	0–1	PAT 21–1	18
0–21	0–1	PBX 21–1	20
0–21	0–1	PBX 21–1MAT	21
24 ± 5%	0–4	PAR–24	17
24 ± 5%	0–4	PWR 24–4	23
24	0–5	PRM 24–5	24-25
Dual 24	0–6	PRM 2X24–6	24-25
24	0–8	PRM 24–8	24-25
24	0–8	PRM 24–8F	24-25
0–25	0–0.2	KG 25–0.2	13
0–25	0–50	KO 25–50M	14
28 ± 5%	0–3.3	PWR 28–3.3	23
28 ± 5%	0–3.7	PAR–28	17
28	0–4.3	PRM 28–4.3	24-25
Dual 28	0–5	PRM 2X28–5	24-25
28	0–7	PRM 28–7	24-25
28	0–7	PRM 28–7F	24-25
0–30	0–0.3	ABC 30–0.3M	6
0–30	0–1.5	CDT 15–1.5M	9
0–36	0–0.3	PAX 36–0.3	19
0–36	0–1.5	CK 36–1.5M	10
0–36	0–1.5	CK 36–1.5MHS	11
0–36	0–5	KS 36–5M	15
0–36	0–5	SM 36–5AM	26
0–36	0–10	KS 36–10M	15
0–36	0–10	SM 36–10AM	26
0–36	0–15	KS 36–15M	15
0–36	0–15	SM 36–15AM	26
0–36	0–30	KS 36–30M	15
36 ± 5%	0–2.8	PAR–36	17
36 ± 5%	0–3	PWR-36–3	23
36	0–3.3	PRM 36–3.3	24-25
Dual 36	0–4	PRM 2X36–4	24-25
36	0–5	PRM 36–5	24-25
36	0–5	PRM 36–5F	24-25
0–19–38	0–5	PR 38–5M	22
0–38	0–15	PR 38–15M	22
0–40	0–0.5	ABC 40–0.5M	6
0–±40	0–±0.5	CDT 40–0.5M	9
0–40	0–0.5	OPS 40–0.5	16
0–40	0–0.5	OPS 40–0.5TA	21
0–40	0–0.5	PAT 40–0.5	18
0–40	0–0.5	PBX 40–0.5	20
0–40	0–0.5	PBX 40–0.5MAT	21
0–40	0–0.8	CK 40–0.8M	10
0–40	0–0.8	CK 40–0.8MHS	11
0–40	0–50	PR 40–50AM	22
0–45	0–30	KO 45–30M	14
48 ± 5%	0–2	PWR 48–2	23
48 ± 5%	0–2.3	PAR–48	17
48	0–2.5	PRM 48–2.5	24-25
Dual 48	0–3	PRM 2X48–3	24-25
48	0–4	PRM 48–4	24-25
48	0–4	PRM 48–4F	24-25
0–50	0–40	PR 50–40AM	22
0–60	0–0.5	CK 60–0.5M	10
0–60	0–0.5	CK 60–0.5MHS	11
0–60	0–2	KS 60–2M	15
0–60	0–5	KS 60–5M	15
0–60	0–10	KS 60–10M	15
0–60	0–20	KS 60–20M	15
60 ± 5%	0–1.5	PWR 60–1.5	23
60 ± 5%	0–2	PAR–60	17
60	0–2	PRM 60–2	24-25
Dual 60	0–2.5	PRM 2X60–2.5	24-25
60	0–3	PRM 60–3	24-25
60	0–3	PRM 60–3F	24-25
0–70	0–20	KO 70–20M	14
0–72	0–0.15	PAX 72–0.15	19
0–72	0–0.3	OPS 72–0.3	16
0–72	0–0.3	OPS 72–0.3TA	21
0–72	0–0.3	PAT 72–0.3	18
0–72	0–0.3	PBX 72–0.3	20
0–72	0–0.3	PBX 72–0.3MAT	21
0–75	0–2	SM 75–2AM	26
0–75	0–5	SM 75–5AM	26
0–75	0–8	SM 75–8AM	26
0–40–80	0–2.5	PR 80–2.5M	22
0–80	0–0.5	CDT 40–0.5M	9
0–80	0–8	PR 80–8M	22
0–100	0–0.05	KG 100–0.05	13
0–100	0–0.1	PAX 100–0.1	19
0–100	0–0.2	ABC 100–0.2M	6
0–±100	0–±0.2	CDT 100–0.2M	9
0–100	0–0.2	OPS 100–0.2	16
0–100	0–0.2	OPS 100–0.2TA	21
0–100	0–0.2	PAT 100–0.2	18
0–100	0–0.2	PBX 100–0.2	20
0–100	0–0.2	PBX 100–0.2MAT	21
0–120	0–1	KS 120–1M	15
0–120	0–2.5	KS 120–2.5M	15
0–120	0–5	KS 120–5M	15
0–120	0–10	KS 120–10M	15
120	0–1	PRM 120–1	24-25
120	0–1.5	PRM 120–1.5	24-25
120	0–1.5	PRM 120–1.5F	24-25
0–78–155	0–1	PR 155–1M	22
0–155	0–4	PR 155–4M	22
0–160	0–1	SM 160–1AM	26
0–160	0–2	SM 160–2AM	26
0–160	0–4	SM 160–4AM	26
0–200	0–0.1	ABC 200M	7
0–200	0–0.2	CDT 100–0.2M	9
0–220	0–3	PR 220–3M	22
0–250	0–1	HB 250M	12
Dual 0–300	0–0.075	103 Unregulated	27
0–165–310	0–0.6	PR 310–0.6M	22
0–310	0–2	PR 310–2M	22
0–165–325	0–0.5	SM 325–0.5AM	26
0–325	0–0.2	HB 2AM	12
0–325	0–0.4	HB 4AM	12
0–325	0–0.6	HB 6AM	12
0–325	0–0.8	HB 8AM	12
0–325	0–1	SM 325–1AM	26
0–325	0–2	SM 325–2AM	26
0–400	0–0.15	400B	27
Dual 0–400	0–0.15	2400B	27
0–425	0–0.05	ABC 425M	7
Dual 0–450	0–0.3	430D	27
0–500	0–0.4	BHK 500–0.4M	8
0–525	0–0.5	HB 525M	12
Dual 0–600	0–0.2	800B	27
0–600	0–0.3	615B	27
0–600	0–0.5	605	27
0–1000	0–0.02	ABC 1000M	7
0–1000	0–0.2	BHK 1000–0.2M	8
0–1000	0–0.5	1250B	27
0–1500	0–0.01	ABC 1500M	7
0–1500	0–0.2	1520B	27
0–2000	0–0.1	BHK 2000–0.1M	8
0–2000	0–0.5	HB 2050	27
0–2000	0–0.01	OPS–2000	16
0–2500	0–0.002	ABC 2500M	7
0–2500	0–0.05	HB 2500	12

ORDERING INFORMATION:

Power supplies are identified by a multipart model number, usually comprising a letter group prefix (identifying the design), a series of numbers that specify the model, and various suffix letters that define the options, meters, control locks, etc. *Please use the full Kepco model number* when ordering — even if local specification control numbers are assigned by your organization.

Most models are maintained in stock for delivery within two (2) days. Out-of-stock items are usually deliverable within thirty (30) days. Check with your local sales representative, who receives weekly stock reports.

Shipment may be made via motor freight or UPS, at your option. Liaison is also maintained with all New York airports and piers.

WARRANTY:

All Kepco products are backed by a firm one (1) year warranty, covering all parts and labor. The warranty is honored at our factory service department, Flushing, New York, and at field service depots maintained at strategic cities. Service may also be obtained through Kepco's factory-trained field representatives whose addresses are listed on page 47 of this catalog.

PARTS:

Maintenance parts may be obtained through the field representative or from Kepco directly. When ordering parts, please use the identifying Kepco part number, and give the model and serial number of the instrument for which they are intended. Do not return any parts to Kepco unless authorization tags and instructions are provided.

COMMUNICATIONS:



Address all mail to:
Kepco, Inc., 131-38 Sanford Avenue, Flushing, N.Y. 11352
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TWX Number: 710-582-2631
Telex: 12-6055
Cable Address: KEPCOPOWER NEWYORK

APPLICATIONS ASSISTANCE:

Questions concerning the facilities, features, behavior, and characteristics of any product may be directed to the Kepco Applications Engineering Department. A staff of specialists is happy to provide any assistance in the application of Kepco's Power Supplies to your requirements.

KEPCO LITERATURE

This catalog is one of a number of Kepco publications designed to assist you in the selection and application of Regulated Power Supplies. Kepco publications include: "Kepco Power Supply Handbook", reprints of current technical papers and a quarterly newspaper, the Kepco Power Supply News.

KEPCO POWER SUPPLY HANDBOOK

The Handbook covers the subject of Regulated DC Power Supplies in detail with particular emphasis on the operational concept, and its application to systems design.

TECHNICAL PAPERS

Kepco's engineers are continuously engaged in a research effort to extend the dimensions of the Power Supply art. Their work is regularly published and reprints are available to interested Power Supply users.

KEPCO POWER SUPPLY NEWS

A technical journal published quarterly with articles and news stories reporting developments in the Power Supply field.

For a complimentary copy of the "Kepco Power Supply Handbook", reprints of technical papers, or a subscription to the Kepco Power Supply News, write: Publications Manager, KEPCO, INC., Dept. 678
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Copies of these Kepco publications are also available through Kepco's field representatives.

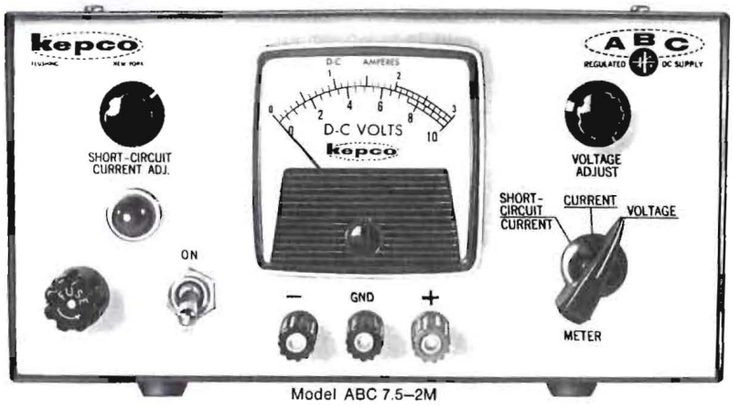
KEPCO

ABC

ALL-TRANSISTOR

POWER SUPPLIES

- *voltage and current regulation*
- *10-turn voltage control*
- *operationally programmable*



Model ABC 7.5–2M

MODEL	DC OUTPUT RANGE		RIPPLE (MAX.) RMS	OUTPUT IMPEDANCE Ohms + Microhenries			MAX. INPUT AMPS
	VOLTS	AMPS	mV	DC to 100 cps	100 cps to 1kc	1 kc to 100 kc + μh	at 125 V AC
ABC 2–1M	**0–2**	**0–1**	0.25	0.001	0.01	0.1 + 0.5	0.3
ABC 7.5–2M	**0–7.5**	**0–2**	0.25	0.002	0.01	0.05+ 0.5	0.5
ABC 10–0.75M	**0–10**	**0–0.75**	0.25	0.007	0.02	0.1 + 1	0.3
ABC 15–1M	**0–15**	**0–1**	0.25	0.008	0.01	0.05+ 0.5	0.5
ABC 18–0.5M	**0–18**	**0–0.5**	0.25	0.02	0.02	0.1 + 1	0.3
ABC 30–0.3M	**0–30**	**0–0.3**	0.25	0.05	0.02	0.1 + 1	0.3
ABC 40–0.5M	**0–40**	**0–0.5**	0.25	0.04	0.02	0.05 + 0.5	0.5

SPECIFICATION	VOLTAGE MODE	CURRENT MODE** (External Sensing)
OUTPUT RANGE	0–100% E_O max.	1 mA to 100% I_O
REGULATION, LINE	<0.05% or 1 mV*	<0.1% at rated sample**
REGULATION, LOAD	<0.05% or 1 mV*	<0.5% at rated sample**
STABILITY (8 HR.)	<0.05% or 3 mV*	<0.1% or 1 mA*
TEMP. COEFFICIENT	<0.05% per °C	<0.1% per °C at rated sample**
RIPPLE, rms	<0.25 mV	<0.1% of I_O max.

**whichever is greater*
***Rated sample is 1V DC across external current sampling resistor, with external current control.*

INPUT: 105-125V AC or 210-250V AC (selected), 50-440 cps, single phase

TEMPERATURE, AMBIENT OPERATING: –20°C to +50°C.

TEMPERATURE, STORAGE: –40°C to +85°C.

COOLING: Convection.

ISOLATION VOLTAGE: 500 volts to chassis.

CONTROL RESOLUTION: 0.05%, 10-turn voltage control.

PROGRAMMING: 1 mA control current, by resistance at 1000 ohms per volt. May be controlled operationally as an amplifier using voltage or current signals; common negative.

VOLTAGE RECOVERY: (for step load current): <50 microseconds.

CURRENT LIMITING: Single turn panel adjustment sets limit from 25% to 150% of rated full current.

REMOTE ERROR SENSING: Compensates up to 0.5V drop per output lead.

OVERSHOOT: (Turn-on/off): None above 25% voltage setting. Negligible below 25% when preloaded to 10% minimum.

SERIES/PARALLEL: Series operation to rated isolation; also master/slave capability. Current limiting design permits self-determined parallel load sharing.

METERS: The suffix "M" designates a single dual scale voltammeter, 2½", 2%, with selector switch. Delete suffix for unmetered unit.

TERMINALS: Binding posts on front panel, plus, minus and ground. Multi-terminal barrier strip at rear contains output, sensing and control terminals.

DIMENSIONS: 4¼"H x 8$\frac{5}{32}$"W x 9$\frac{5}{8}$"D for Models ABC 7.5-2M, ABC 15-1M, ABC 40-0.5M and ABC 100-0.2M; 4¼"H x 8$\frac{5}{32}$"W x 5$\frac{5}{8}$"D for Models ABC 2-1M, ABC 10-0.75M, ABC 18-0.5M and ABC 30-0.3M.

FINISH: *Panel:* etched aluminum; *Case:* gray hammertone.

MOUNTING: Bench style. Rack mounting adapter for single or dual mounting available. See Accessory pages.

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

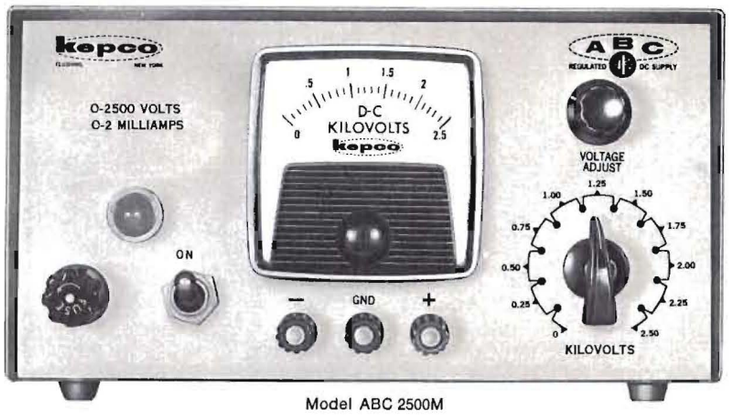
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PATENT NOTICE Applicable Patent Nos. will be supplied on request.

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kepco®

KEPCO
ABC
HYBRID
POWER SUPPLIES

- *hybrid tube/transistor regulator*
- *voltage and current regulation*
- *10-turn voltage control*
- *operationally programmable*



Model ABC 2500M

MODEL	DC OUTPUT RANGE		RIPPLE (MAX.) RMS	OUTPUT IMPEDANCE Ohms + Microhenries			MAX. INPUT AMPS
	VOLTS	mA	mV	DC to 100 cps	100 cps to 1kc	1 kc to 100 kc+μh	at 125 V AC
ABC 200M	**0–200**	**0–100**	0.5	1	0.5	2.0 + 2.0	0.5
ABC 425M	**0–425**	**0–50**	0.5	4	0.5	2.0 + 2.0	0.5
ABC 1000M	**0–1000**	**0–20**	1.0	25	1.0	2.0 + 10.0	0.5
ABC 1500M	**0–1500**	**0–10**	1.0	75	1.0	2.0 + 10.0	0.3
ABC 2500M	**0–2500**	**0–2**	1.0	625	1.0	2.0 + 10.0	0.3

SPECIFICATION	VOLTAGE MODE	CURRENT MODE** (External Sensing)
OUTPUT RANGE	0–100% E_O max.	1 mA–100% I_O max.
REGULATION, LINE	<0.05% or 5 mV*	<0.1% at rated sample**
REGULATION, LOAD	<0.05% or 5 mV*	<0.1% at rated sample**
STABILITY (8 HR.)	<0.05% or 50 mV*	<0.1% or 10 μA*
TEMP. COEFFICIENT	<0.05% per °C	<0.1% per °C at rated sample**
RIPPLE, rms.	See Table above	<0.1% I_O max.

**whichever is greater*
***Rated sample is 10V DC across external current sampling resistor, with external current control.*

INPUT: 105-125V AC or 210-230V AC, (selected), 50-440 cps single phase.

TEMPERATURE, AMBIENT OPERATING: –20°C to +55°C.

TEMPERATURE, STORAGE: –40°C to +85°C.

COOLING: Convection.

ISOLATION VOLTAGE: 1000 volts to chassis.

AC OUTPUT: 6.5V AC, 2A unregulated, available at the rear terminals of Models ABC 200M and ABC 425M.

CONTROL RESOLUTION: 0.05%, 10-turn voltage control on Models ABC 200M and ABC 425M. Resolution is 0.005% with 10-position selector and 10-turn vernier voltage control on Models ABC 1000M, ABC 1500M and ABC 2500M.

PROGRAMMING: 1 mA control current, by resistance at 1000 ohms per volt. May be operationally controlled as an amplifier using voltage or current signals; common positive.
Model ABC 2500M is restricted to the upper ⅔ of its output range in operational control. Fast slewing models available on special order.

VOLTAGE RECOVERY (for step load current): <50 μseconds.

CURRENT LIMITING: Single turn panel adjustment sets limit from 25% to 150% of rated full current on Models ABC 200M and ABC 425M. A fixed limit set to approximately 150% is provided on Models ABC 1000M, ABC 1500M and ABC 2500M.

OVERSHOOT: (Turn-on/off): None above 25% voltage setting; negligible below 25% when preloaded to 10% minimum.

SERIES/PARALLEL: Series operation to rated isolation; also master/slave capability. Current limiting design permits self-determined parallel load sharing.

METERS: Suffix "M" designates a single dual scale 2½", 2% volt-ammeter with selector switch, for models ABC 200M and ABC 425M. Voltmeter only for Models ABC 1000M, ABC 1500M and ABC 2500M.
Delete suffix "M" for unmetered unit.

TERMINALS: Binding posts on front panel, plus, minus and ground. Multi-terminal barrier strip at the rear contains output and control terminals.

DIMENSIONS: 4¼"H x 8⅝"W x 9⅝"D for all models except 13⅝"D for Model ABC 2500M.

FINISH: *Panel:* etched aluminum; *Case:* gray hammertone.

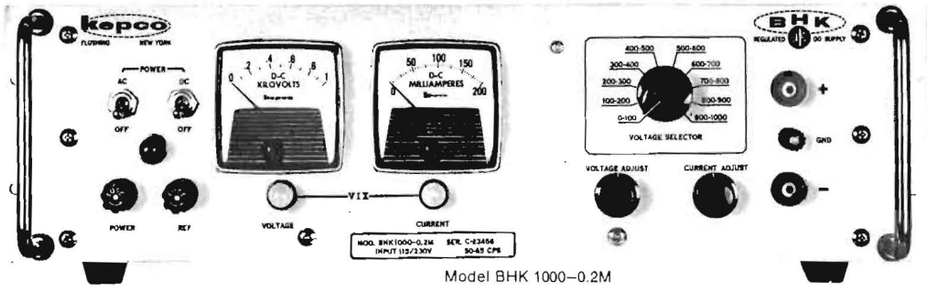
MOUNTING: Bench style. Rack mounting adapter for single or dual mounting available. See Accessory pages.

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

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PATENT NOTICE: Applicable Patent Nos. will be supplied on request.

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Model BHK 1000–0.2M

KEPCO BHK

HIGH VOLTAGE POWER SUPPLIES

■ *fast slewing capability* ■ *operationally controlled*
■ *hybrid design* ■ *10-turn voltage and current controls*

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	OUTPUT IMPEDANCE Ohms + Microhenries DC-100 cps	0.1-1kc	1-100kc
BHK 500–0.4M	**0–500**	**0–0.4**	0.13	0.1	0.2 + 0.5
BHK 1000–0.2M	**0–1000**	**0–0.2**	0.5	0.1	0.2 + 0.5
BHK 2000–0.1M	**0–2000**	**0–0.1**	2.0	0.1	0.2 + 0.5

SPECIFICATIONS	VOLTAGE REGULATION	CURRENT REGULATION (Internal Sensing)	VOLTAGE AMPLIFIER OFFSETS** ΔE_{io}	ΔI_{io}
OUTPUT RANGE:	0-100% E_O max.	0.2%-100% I_O max.	——	——
LINE: 105-125/210-250V AC	<0.005% or 1 mV*	<100 μA	<1 mV	<10 nA
LOAD: No load/full load	<0.01% or 1 mV*	<100 μA	<1 mV	<10 nA
TIME: 8 hours (Stability)	<0.01% or 2.0 mV*	<0.01% or 20μA*	<50 μV	<50 nA
TEMP: Per °C (Coefficient)	<0.01%	<0.05% of I_O max.	<100 μV	<50 nA
RIPPLE: rms (Normal Speed)	<1 mV	<100 μA	——	——

**whichever is greater*
*** E_{io} is the offset voltage and I_{io} is the offset current referred to the input of the voltage comparison amplifier.*

DC VOLTAGE GAIN: More than 100 db.
OUTPUT SLEWING RATE: *(Fast slewing connection):* Greater than 500,000 volts per second [0.5V/μsec.], measured as the chord to the first time constant on the exponential response.
SINUSOIDAL FREQUENCY RESPONSE:
Fast Slewing Connection: $f_{max} = \frac{160}{E_{pp}}$ kc.
(E_{pp} is the peak-to-peak excursion).
RIPPLE, Fast Slewing Connection:
Ungrounded: More than 60 db below peak output.
Grounded: More than 100 db below peak output.
TRANSIENT RESPONSE:
Voltage Mode, Fast Slewing: For step load current, recovery is an exponential with a 50 microsecond time constant.
Current Mode, Fast Slewing: For step load voltage, recovery is at the rate of 0.5 volt per microsecond.
Voltage Mode, Normal Speed: For step load current, recovery to regulation band within 50 microseconds.
OUTPUT IMPEDANCE:
Voltage Mode, Normal Speed: See table.
Voltage Mode, Fast Slewing: Above 1kc, add the reactive impedance of 500 microhenries.
OFFSET NULLING: The initial part of the input offset voltage and input offset current can be nulled with internal controls.
REFERENCES: Two: +6.2 volts and –6.2 volts; maximum current 1 milliampere.
PROGRAMMING: 1 mA control current, by resistance at 1000 ohms per volt. May be operationally controlled as an amplifier using voltage or current signals. Common positive.

AUTOMATIC CROSSOVER: Selects voltage regulation or current regulation operating mode automatically.
VIX® CIRCUIT: Voltage/Current mode indicators display operating conditions; also 115V AC control signal (0.5A max.)
REMOTE ERROR SENSING: Compensates up to 0.5V drop per output lead.
TEMPERATURE, AMBIENT OPERATING: –20°C to +55°C.
TEMPERATURE, STORAGE: –40°C to +85°C.
COOLING: Convection.
INPUT: 105-125 V AC or 210-250V AC (selected), 50-65 cps single phase. Approximately 4 amperes at 125V AC.
ISOLATION VOLTAGE: 1000 volts to chassis.
CONTROL RESOLUTION: Voltage: 0.01% 10-turn vernier control and 10 position selector. Current: 0.05% 10-turn control.
OVERSHOOT: (Turn-on/off): None above 10% voltage setting; negligible below 10% when preloaded to 10% minimum.
SERIES/PARALLEL: Automatic crossover design permits self-determined parallel load sharing, or use of master/slave connection. Series operation to rated isolation.
METERS: Suffix "M" designates a pair of 2½", 2% meters. Delete suffix "M" for unmetered unit.
TERMINALS: Safety (recessed) output connections on front panel; two multi-terminal barrier strips at the rear contain output, sensing and control functions. Fast slewing/normal strapping is internal.
DIMENSIONS: 5¼"H x 19"W x 16½"D (behind panel).
FINISH: Per FED. STD. 595. Color 26440, (light gray).

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

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PATENT NOTICE: Applicable Patent Nos. will be supplied on request.

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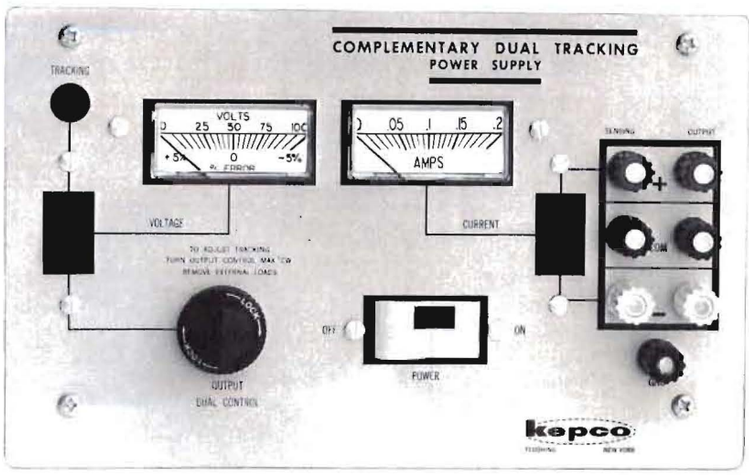
KEPCO

CDT

DUAL TRACKING

POWER SUPPLIES

- *complementary or series output*
- *single control, adjustable tracking*
- *voltage, current and error metering*



Model CDT 100–0.2 M

MODEL	TWIN OUTPUTS* COMPLEMENTARY SERIES				INDIVIDUAL SUPPLIES OUTPUT IMPEDANCE Ohms + Microhenries			MAX. INPUT AMPS
	VOLTS	AMPS	VOLTS	AMPS	DC-100 cps	0.1-1kc	1-100kc	at 125V AC
CDT 15–1.5M	0–±15	0–±1.5	0–30	0–1.5	0.001	0.02	0.1+1μh	1.3
CDT 40–0.5M	0–±40	0–±0.5	0–80	0–0.5	0.008	0.02	0.1+1μh	0.8
CDT 100–0.2M	0–±100	0–±0.2	0–200	0–0.2	0.05	0.02	0.1+1μh	0.9

*Each Power Supply contains two sources with a common voltage control, may be used as complementary (plus and minus) supplies or in series for double voltage.

SPECIFICATION	VOLTAGE MODE COMPLEMENTARY**	SERIES
OUTPUT RANGE	0 to $+E_O$ and 0 to $-E_O$	0 to twice E_O
REGULATION, LINE	<0.005%	<0.005%
REGULATION, LOAD	<0.01% or 1mV*	<0.01% or 2mV*
STABILITY (8 hr)	<0.01% or 2mV*	<0.01% or 4mV*
TEMP. COEFFICIENT	<0.01% per °C	<0.01% per °C
RIPPLE, rms	<0.25mV	<0.5mV

*whichever is greater

**Specifications are for the individual supplies, changes in the master supply (plus output) are repeated 1:1 in the slave supply.

INPUT: 105-125V AC or 210-250V AC (selected) 50-440 cps.

TEMPERATURE, AMBIENT OPERATING: –20°C to +65°C.

TEMPERATURE, STORAGE: –40°C to +85°C.

COOLING: Convection.

ISOLATION VOLTAGE: 500 volts to chassis.

OUTPUT: The individual power supplies are wired in series, controlled with a single voltage control. They may be loaded in series or separately.

CONTROL RESOLUTION: <0.05%, 10 turn voltage control adjusts the output of the positive supply, designated "master", this voltage in turn controls the negative supply or "slave" in a 1:1 ratio. The two power supplies are connected in series.

TRACKING: ±5% range of adjustment is controlled by a recessed front panel control. Units can be adjusted to within ±0.5% using panel meter. Closer adjustment with external instrumentation.

PROGRAMMING: 1 milliampere control current, or resistance: 1000 ohms per volt. Common positive.

VOLTAGE RECOVERY, (for step load current): <50 μseconds.

CURRENT LIMITING: Each supply is individually limited with a 10 to 105% range of adjustment.

REMOTE ERROR SENSING: Compensates for up to 0.5 volt drop per output lead.

METERS: Voltmeter monitors output of MASTER, or the difference between MASTER and SLAVE, displayed as a percentage error (range ±5%). Ammeter monitors current from either supply (selectable).

TERMINALS: Binding posts on the front panel for plus, common and minus outputs, also sensing terminals and separate ground. Barrier strip at the rear has duplicate output, sensing and control terminals.

DIMENSIONS: 5¼"H x 8$^{11}/_{32}$"W x 17¾"D (behind panel).

FINISH: *Panel:* Per FED. STD. 595. Color 26440, (light gray). *Case:* Gray hammertone.

MOUNTING: Rack Adapters available, see accessory page.

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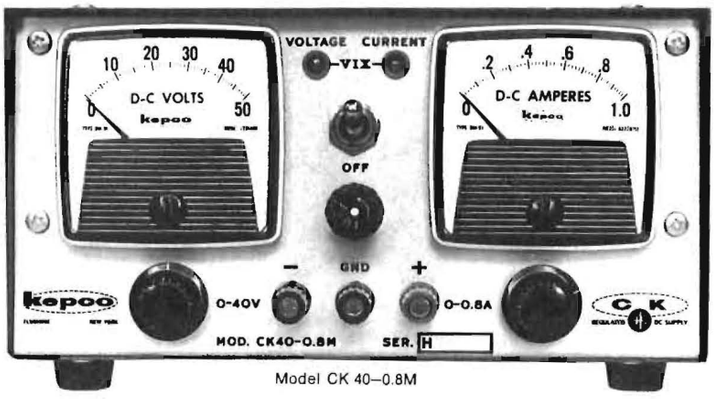
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KEPCO
CK

AUTOMATIC CROSSOVER
POWER SUPPLIES

- *VIX® indicators, automatic crossover*
- *10-turn voltage and current controls*
- *operationally programmable*



Model CK 40–0.8M

MODEL	DC OUTPUT RANGE		OUTPUT IMPEDANCE Ohms + Microhenries			MAX. INPUT AMPS at 125 V AC
	VOLTS	AMPS	DC to 100 cps	100 cps to 1 kc	1 kc to 100 kc +μh	
CK 2–8M	0–2	0–8	0.065×10^{-3}	0.01	0.05+0.5	1
CK 8–5M	0–8	0–5	0.16×10^{-3}	0.01	0.05+0.5	1.2
CK 18–3M	0–18	0–3	0.6×10^{-3}	0.01	0.05+0.5	1.3
CK 36–1.5M	0–36	0–1.5	2.4×10^{-3}	0.02	0.08+0.8	1.5
CK 40–0.8M	0–40	0–0.8	5×10^{-3}	0.02	0.08+0.8	1
CK 60–0.5M	0–60	0–0.5	12×10^{-3}	0.02	0.08+0.8	1

SPECIFICATION	VOLTAGE MODE	CURRENT MODE (Internal Sensing)	CURRENT MODE ** (External Sensing)
OUTPUT RANGE	0–100% E_O max.	0.2%–100% I_O max.	1 mA–100% I_O max.
REGULATION, LINE	<0.005% or 0.1 mV*	<0.01% or 0.2 mA*	<0.01% at rated sample**
REGULATION, LOAD	<0.01% or 0.5 mV*	<0.01% or 0.2 mA*	<0.01% at rated sample**
STABILITY (8 HR.)	<0.01% or 2.0 mV*	<0.05% or 1 mA*	<0.05% or 1 mA*
TEMP. COEFFICIENT	<0.01% per °C	<0.05% of I_O max. per °C	<0.05% per °C at rated sample**
RIPPLE, rms	<0.5 mV	<0.05% of output setting or 0.01% of I_O max.*	

**whichever is greater*
***Rated Sample is 1.0V DC across external current sampling resistor with external current control*

INPUT: 105-125V AC or 210-250V AC (selected), 50-65 cps, single phase.

TEMPERATURE, AMBIENT OPERATING: –20°C to +50°C
TEMPERATURE, STORAGE: –40°C to +85 C

COOLING: Forced air lateral circulation. Built-in blower.

ISOLATION VOLTAGE: 500 volts to chassis.

CONTROLS: Independent 10-turn controls for voltage and current. **Resolution:** 0.05%.

PROGRAMMING: 1 mA control current, by resistance at 1000 ohms per volt. May be operationally controlled as an amplifier, using voltage or current signals; common negative. Voltage and current regulators may be independently programmed.

VOLTAGE RECOVERY, (for step load current): 50 microseconds.

AUTOMATIC CROSSOVER: Selects voltage regulation or current regulation operating mode automatically.

VIX CIRCUIT: Mode indicators display operating condition, a ±8V, ±1 mA control signal is provided at rear terminals.

REMOTE ERROR SENSING: Compensates up to 0.5V drop per output lead.

OVERSHOOT: (Turn-on/off): None above 25% voltage setting; negligible below 25% when preloaded to 10% minimum.

SERIES/PARALLEL: Automatic crossover design permits self-determined paralellel load-sharing; also master/slave capability. Series operation to rated isolation.

METERS: Suffix "M" designates a pair of 2½ inch, 2% meters. Delete suffix for unmetered unit.

TERMINALS: Binding posts on front panel, plus, minus, and ground. Sixteen (16) terminal barrier strip on rear contains output, sensing and control terminals.

DIMENSIONS: 4¼"H x 8⁵⁄₃₂"W x 13"D (behind rack adapter), 13⅜"D (overall).

FINISH: Panel etched aluminum; case, gray hammertone.

MOUNTING: Bench style, single and dual rack mounting adapters available, see accessory pages.

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

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PATENT NOTICE: Applicable Patent Nos. will be supplied on request.

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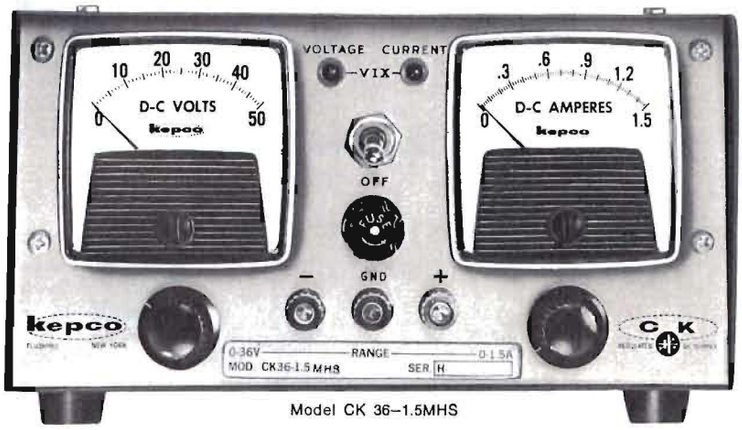
KEPCO

CK-HS

UNIPOLAR AMPLIFIER

POWER SUPPLIES

- *fast slewing*
- *automatic crossover*
- *adjustable offsets*



Model CK 36–1.5MHS

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	MAX. INPUT AMPS at 125 V AC
CK 8–5MHS	**0–8**	**0–5**	1.2
CK 18–3MHS	**0–18**	**0–3**	1.3
CK 36–1.5MHS	**0–36**	**0–1.5**	1.5
CK 40–0.8 MHS	**0–40**	**0–0.8**	1.0
CK 60–0.5MHS	**0–60**	**0–0.5**	1.0

PARAMETER	VOLTAGE REGULATION	CURRENT REGULATION (Internal Sensing)	VOLTAGE AMPLIFIER OFFSETS** ΔE_{io}	ΔI_{io}
OUTPUT RANGE	0-100% E_O max.	0.2%-100% I_O max.	——	——
LINE: 105-125/210-250V AC	<0.005% or 0.1 mV*	<0.005% or 0.2 mA*	<0.1 mV	<10 nA
LOAD: No load/full load	<0.01% or 0.5 mV*	<0.01% or 0.2 mA*	<0.5 mV	<10 nA
TIME: 8 hours (Stability)	<0.01% or 2.0 mV*	<0.05% or 1 mA*	<0.1 mV	<50 nA
TEMP: Per C (Coefficient)	<0.01%	<0.05% of I_O max.	<0.5 mV	<100 nA

**whichever is greater*

***E_{io} is the offset voltage and I_{io} is the offset current referred to the input of the voltage comparison amplifier.*

DC VOLTAGE GAIN: More than 90 db.

OUTPUT SLEWING RATE: > 100,000 volts / second (0.1V/μsec.) measured as the slope of the chord to the first time constant on the exponential response.

SINUSOIDAL FREQUENCY RESPONSE: $f_{max.} = \frac{32}{E_{pp}}$ kc.

(E_{pp} is the peak-to-peak voltage excursion.)

MAXIMUM CAPACITANCE LOADING: 0.001 microfards. Excess capacitance slows response and causes peaking of response and instability. Adjustable lag networks provide for small range of load reactance.

RIPPLE: Voltage Mode: 60 db below peak output (grounded)
Current Mode: 46 db below peak output (grounded)

TRANSIENT RESPONSE: Voltage mode *(for step load current)* recovery is an exponential with a 50 microsecond time constant. **Current Mode** *(for step load voltage)* recovery is at the rate of 0.1 volts per microsecond.

OUTPUT IMPEDANCE: At DC $Z_O = \Delta E_O / I_O$; dynamically, add the reactive impedance of 5 millihenries.

OFFSET NULLING: The initial part of the input offset voltage and input offset current can be nulled with internal controls.

REFERENCES: Two; +6.2V and –6.2V; maximum current 1 mA.

AUTOMATIC CROSSOVER: Selects voltage regulation or current regulation operating mode automatically.

VIX* CIRCUIT: Mode indicators display operating conditions, also produce a ±8V, ⁺1 mA control signal.

REMOTE ERROR SENSING: Compensates up to 0.5V drop per output lead.

PROGRAMMING: 1 mA control current by resistance at 1000 ohms per volt. May be operationally controlled as an amplifier using external voltage or current signals; common negative.

INPUT: 105-125V AC or 210-250V AC (selectable), 50-65 cps single phase.

TEMPERATURE, AMBIENT OPERATING: –20°C to +50°C.

TEMPERATURE, STORAGE: –40°C to +85°C.

COOLING: Forced lateral circulation, built-in blower.

ISOLATION VOLTAGE: 500 volts to chassis.

CONTROLS: 10-turn voltage and current controls, 0.05% resolution.

METERS: Suffix "M" designates a pair of 2½", 2% meters. Delete the "M" from the suffix to specify an unmetered unit.

TERMINALS: Binding posts on front panel, plus, minus, and ground. Sixteen (16) terminal barrier strip on the rear contains output, sensing, and control terminals.

DIMENSIONS: 4¼"H x 8⅝"W x 13⅝"D. Half-rack. Mounting accessories available, see accessory pages.

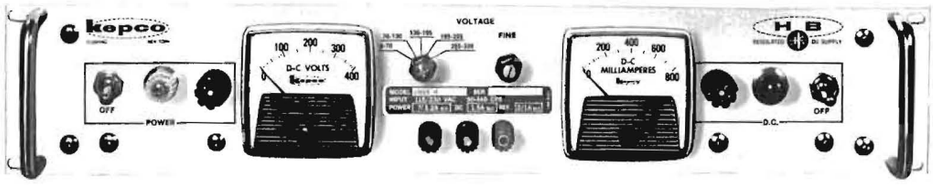
FINISH: *Panel:* brushed aluminum; *Housing:* gray hammertone.

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Model HB 8AM

KEPCO

HB

HYBRID

POWER SUPPLIES

- *hybrid tube/transistor regulator*
- *5-position range, 10-turn voltage control*
- *operationally programmable*

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE mA	OUTPUT IMPEDANCE Ohms + Microhenries DC to 100 cps	100 cps to 1 kc	1 kc to 100 kc +μh	AUXILLIARY OUTPUT 6.5V AC Unregulated	MAX. INPUT AMPS at 125 V AC
HB 2AM	0–325	0–200	0.2	0.08	0.2+0.5	EACH SUPPLY HAS TWO 6 AMPERE OUTPUTS	2.0
HB 4AM	0–325	0–400	0.1	0.08	0.2+0.5		3.0
HB 6AM	0–325	0–600	0.06	0.08	0.2+0.5		5.0
HB 8AM	0–325	0–800	0.05	0.08	0.2+1.0		5.5
HB 250M	0–250	0–1000	0.025	0.08	0.2+0.5		8.0
HB 525M	0–525	0–500	0.1	0.08	0.2+0.5		8.0

SPECIFICATION	VOLTAGE MODE	CURRENT MODE
OUTPUT RANGE	0–100% E_O max.	10 mA–100% I_O max.
REGULATION, LINE	<0.01%	<0.01% at rated sample**
REGULATION, LOAD	<0.01% or 2 mV*	<0.01% at rated sample**
STABILITY (8 HR.)	<0.01% or 2 mV*	<0.05% or 0.2 mA*
TEMP. COEFFICIENT	<0.01% per °C	<0.05% per °C at rated sample**
RIPPLE, rms.	<1 mV	<0.01% of I_O max.

*whichever is greater
**Rated sample is 10V DC across external current sampling resistor, with external current control.

INPUT: 105-125 V or 210-250V AC (selected), 50-440 cps, single phase.

TEMPERATURE, AMBIENT OPERATING: –20°C to +55°C.

TEMPERATURE STORAGE: –40°C to +85°C.

COOLING: Convection.

ISOLATION VOLTAGE: 600 volts to chassis.

AC OUTPUTS: Two unregulated, 6.5V AC, 6A outputs.

CONTROL RESOLUTION: 0.02%, 5 step range selector, 10-turn vernier.

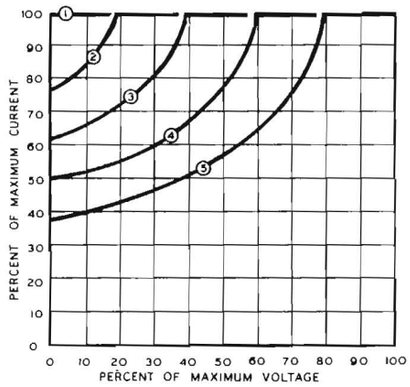
PROGRAMMING: 10 mA control current, by resistance at 100 ohms per volt. May be operationally controlled as an amplifier using voltage or current signals; common positive.

VOLTAGE RECOVERY (for step load current): < 50 microseconds.

REMOTE ERROR SENSING: (Models HB 250M and HB 525M only) compensate up to 0.5 volt drop per output lead.

OVERSHOOT (Turn-on/off): None above 25% voltage setting; negligible below 25% when preloaded 10% minimum.

RATING CURVES: Output is designed to deliver 100% of rated current within the span of any one range. When operating outside the selected range, either by remote programming, or as the compliance voltage in current mode, use the graph to determine the maximum current that can be drawn at reduced voltage.



RATING CURVES

Curves represent the volt-ampere rating for range switch positions 1–5. To use, determine which position covers the desired voltage. Read the maximum current for each voltage on the left scale.

METERS: Suffix "M" designates a pair of 2½", 2% meters. Delete suffix for unmetered unit.

TERMINALS: Binding posts on front panel, plus, minus and ground. Multi-terminal barrier strip at the rear contains output, sensing and control terminals.

DIMENSIONS: 3½"H x 19"W x 14⅜"D (behind front panel).

FINISH: Per FED. STD. 595. Color 26440, (light gray).

MOUNTING: Rack or bench.

All terms used in the specifications are defined in the Kepco Glossary on Page 33

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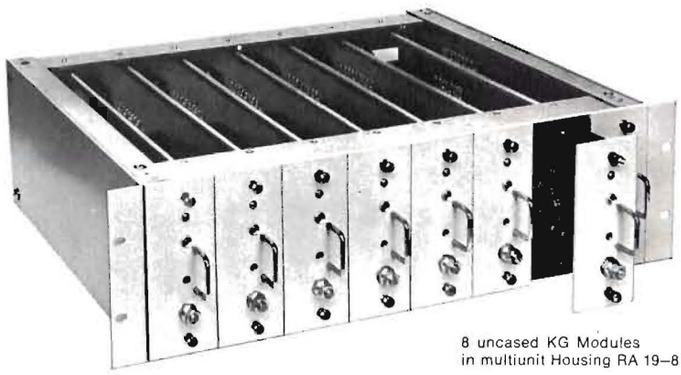
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KG

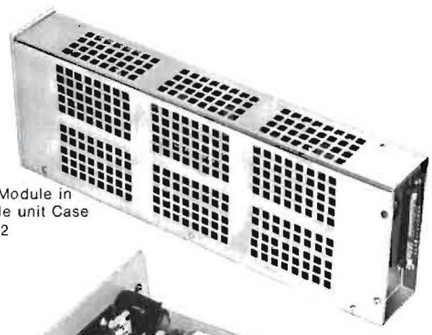
ISOLATED

POWER SUPPLIES

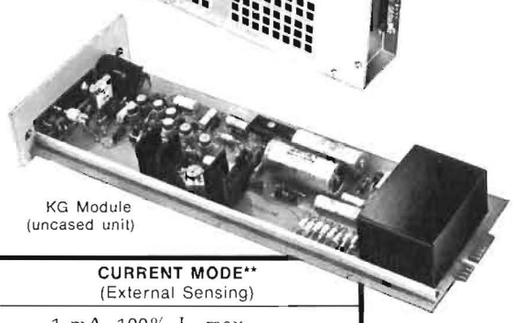
- *isolated from power line*
- *plug-in mount*
- *10-turn voltage control*



8 uncased KG Modules in multiunit Housing RA 19–8



KG Module in single unit Case CA–2



KG Module (uncased unit)

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	OUTPUT IMPEDANCE Ohms + Microhenries DC to 100 cps	100 cps to 1 kc	1 kc to 100 kc + μh	MAX. INPUT AMPS at 125 V AC
KG 25–0.2	**0–25**	**0–0.2**	0.006	0.01	0.1 + 1	0.2
KG 100–0.05	**0–100**	**0–0.05**	0.1	0.01	0.1 + 1	0.2

KG Modules have been especially isolated for minimum common mode signal and least ground coupling to the power line.

SPECIFICATION	VOLTAGE MODE	CURRENT MODE** (External Sensing)
OUTPUT RANGE	0–100% E_O max.	1 mA–100% I_O max.
REGULATION, LINE	<0.001%	<0.001% at rated sample**
REGULATION LOAD	<0.005% or 0.5 mV*	<0.01% at rated sample**
STABILITY (8 HR.)	<0.005% or 1 mV*	<0.01% per C at rated sample**
TEMP. COEFFICIENT	<0.005% per C	<0.01% per C
RIPPLE, rms.	<0.1 mV	<0.01% of I_O max.

**whichever is greater*
***Rated sample is 1V DC across external current sampling resistor, with external current control.*

INPUT: 105-125V AC, 50-65 cps, single phase.
TEMPERATURE, AMBIENT OPERATING: –20°C to +50°C.
TEMPERATURE, STORAGE: –40°C to +85°C.
COOLING: Convection.
ISOLATION: **Volts:** 500 volts to ground, maximum.
Ohms: 10 K megohms to ground, minimum.
Capacitance: 200 picofarads to ground, max.
Leakage: 50 nA to ground, maximum.
Input to output: 1 picofarad, maximum.
CONTROL RESOLUTION: 0.05%, 10-turn voltage control, screwdriver adjustment, with lock.
PROGRAMMING: 1 mA control current, by resistance at 1000 ohms per volt.
VOLTAGE RECOVERY: (for step load current): < 50 microseconds.
CURRENT LIMITING: Recessed panel adjustment from 5% to 110% of rated current.

OVERSHOOT (Turn-on/off): None above 25% voltage setting; negligible below 25% when preloaded to 10% minimum.
SERIES/PARALLEL: Current limiting design permits self-determined parallel load-sharing. Series operation to rated isolation.
TERMINALS: All connections are made through printed circuit connector in housing, AC input, DC output, sensing and control. A blank terminal is provided which can be wired for operational control using voltage or current signals.
DIMENSIONS: *Panel:* 2 3/16" x 5 7/32"; PC connector 13 19/32" behind panel. *Single unit housing:* (CA-2) 2 5/16"W x 5 1/32"H x 14"L includes mounted PC connector, PC-1. *Multiunit housing:* (RA-19-8) 19"W x 5 1/4"H x 14"D, includes 8 mounted PC connectors, PC-1.
MOUNTING: The uncased KG Module has no mounting provisions. It must be plugged into either a single or multiunit housing for connections and support.
FINISH: Per FED. STD. 595. Color 26440, (light gray).

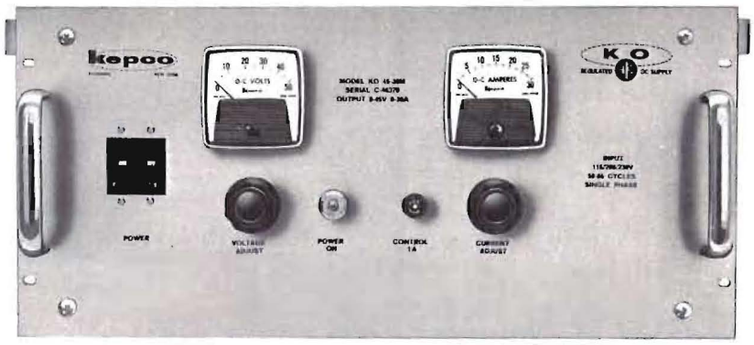
All terms used in the specifications are defined in the Kepco Glossary on Page 33

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PATENT NOTICE. Applicable Patent Nos. will be supplied on request.

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POWER SUPPLIES



Model KO 45-30M

- *silicon controlled rectifier regulator*
- *10-turn voltage and current controls*
- *automatic crossover*

MODEL	DC OUTPUT RANGE		RIPPLE RMS	OUTPUT IMPEDANCE Ohms + μh		MAX. INPUT at 125V AC	
	VOLTS	AMPS	% MV.	1 kc to 10 kc	10 kc to 100 kc	AMPS	WATTS
KO 12–100M	**0–12**	**0–100**	0.5 or 30	0.02	0.04+0.5	24	1800
KO 25–50M	**0–25**	**0–50**	0.5 or 40	0.02	0.04+0.5	24	1800
KO 45–30M	**0–45**	**0–30**	0.3 or 20	0.02	0.04+0.5	24	1800
KO 70–20M	**0–70**	**0–20**	0.3 or 30	0.02	0.04+0.5	24	1800

SPECIFICATION	VOLTAGE MODE	CURRENT MODE** (Internal Sensing)
OUTPUT RANGE	0–100% E_O max.	10%–100% I_O max.
REGULATION, LINE	<1%	<2% or 200 mA*
REGULATION, LOAD	<1% or 20 mV*	<2% or 200 mA* **
STABILITY (8 HR.)	<1% or 50 mV*	<2% or 200 mA*
TEMP. COEFFICIENT	<0.1% per °C	<0.5% of I_O max. per °C
RIPPLE, rms	See Table	<0.5% of I_O max.

**whichever is greater*
***compliance range: 0.25V to 100% E_O max.*

INPUT: 105-125V AC or 210-250V AC, (selected), 50-65 cps, single phase.

TEMPERATURE, AMBIENT OPERATING: –20°C to +50°C

TEMPERATURE, STORAGE: –40°C to +85°C.

COOLING: Forced air lateral circulation, built-in blowers.

ISOLATION VOLTAGE: 500 volts to chassis.

CONTROL RESOLUTION: 0.05%, independent 10-turn controls for voltage and current.

PROGRAMMING: Voltage control approximately 100 ohms per volt, (10 mA control current) Current control approximately 1000 ohms per volt, (1 mA control current).

VOLTAGE RECOVERY: (for step load current, 0-100% and 100%-10%): <500 milliseconds.

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

AUTOMATIC CROSSOVER: Selects voltage regulation or current regulation operating mode automatically.

REMOTE ERROR SENSING: Compensates up to 0.5V drop per output lead.

SERIES/PARALLEL: Automatic crossover design permits self-determined parallel load sharing; also master/slave capability. Series operation to rated isolation.

METERS: Suffix "M" designates a pair of 2½" 2% meters. Delete suffix "M" for unmetered unit.

TERMINALS: Heavy duty output connectors at rear. A multi-terminal barrier strip contains sensing and control functions.

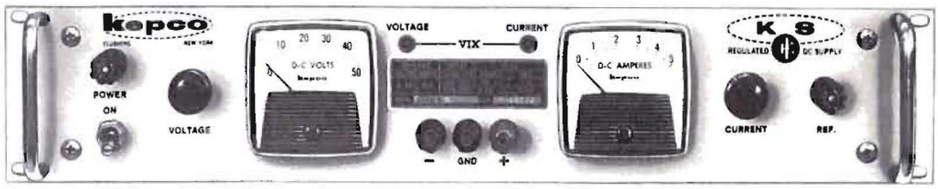
DIMENSIONS: 8¾"H x 19"W x 20"D (behind panel). Side handles and skids removable for rack mounting.

FINISH: Per FED. STD. 595. Color 26440, (light gray).

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Model KS 36–5M

KEPCO
KS
AUTOMATIC CROSSOVER
POWER SUPPLIES

- *VIX® indicators, automatic crossover*
- *10-turn voltage and current controls*
- *operationally programmable*

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	OUTPUT IMPEDANCE Ohms + Microhenries DC to 100 cps	100 cps to 1 kc	1 kc to 100 kc + μh	SIZE	MAX. INPUT at 125V AC AMPS	MAX. INPUT at 125V AC WATTS
KS 8–15M	0–8	0–15	0.05×10^{-3}	0.01	0.04+0.4	A	4.4	320
KS 8–25M	0–8	0–25	0.03×10^{-3}	0.01	0.04+0.4	B	8.5	565
KS 8–50M	0–8	0–50	0.016×10^{-3}	0.005	0.02+0.4	C	15.5	1000
KS 8–100M	0–8	0–100	0.008×10^{-3}	0.005	0.02+0.4	D	34.0	2100
KS 18–10M	0–18	0–10	0.18×10^{-3}	0.01	0.04+0.5	A	6.7	345
KS 18–15M	0–18	0–15	0.12×10^{-3}	0.01	0.04+0.5	B	8.0	510
KS 18–25M	0–18	0–25	0.07×10^{-3}	0.005	0.04+0.5	C	14.0	900
KS 18–50M	0–18	0–50	0.035×10^{-3}	0.005	0.02+0.2	D	26.0	1800
KS 36–5M	0–36	0–5	0.7×10^{-3}	0.02	0.1 +1.0	A	4.8	290
KS 36–10M	0–36	0–10	0.4×10^{-3}	0.01	0.1 +1.0	B	8.9	580
KS 36–15M	0–36	0–15	0.25×10^{-3}	0.01	0.1 +0.6	C	12.2	860
KS 36–30M	0–36	0–30	0.1×10^{-3}	0.005	0.04+0.4	D	25.0	1600
KS 60–2M	0–60	0–2	3×10^{-3}	0.02	0.1 +1.0	A	3.0	250
KS 60–5M	0–60	0–5	1×10^{-3}	0.02	0.1 +1.0	B	7.0	500
KS 60–10M	0–60	0–10	0.6×10^{-3}	0.01	0.1 +1.0	C	13.0	1000
KS 60–20M	0–60	0–20	0.3×10^{-3}	0.01	0.1 +0.8	D	24.0	1700
KS 120–1M	0–120	0–1	10×10^{-3}	0.02	0.1 +1.0	A	3.0	250
KS 120–2.5M	0–120	0–2.5	5×10^{-3}	0.02	0.1 +1.0	B	7.0	500
KS 120–5M	0–120	0–5	3×10^{-3}	0.01	0.1 +1.0	C	13.0	1000
KS 120–10M	0–120	0–10	1×10^{-3}	0.01	0.1 +1.0	D	24.0	1700

DIMENSIONS:

SIZE	H"	W"	D"
A	3½	19	14⅜
B	5¼	19	16
C	7	19	16
D	8¾	19	20

SPECIFICATION	VOLTAGE MODE	CURRENT MODE (Internal Sensing)	CURRENT MODE** (External Sensing)
OUTPUT RANGE	0–100% E_O max.	<0.5%–100% I_O max.	10 mA–100% I_O max.
REGULATION, LINE	<0.005%	<0.01% or 1 mA*	<0.01% at rated sample**
REGULATION, LOAD	<0.01% or 0.5 mV*	<0.01% or 1 mA*	<0.01% at rated sample**
STABILITY (8 HR.)	<0.01% or 3 mV*	<0.05% or 5mA*	<0.05% per °C at rated sample**
TEMP. COEFFICIENT	<0.01% per °C	<0.05% of I_O max. per °C	<0.05% per °C at rated sample**
RIPPLE, rms.	<1 mV	<0.1% of setting or 0.05% of I_O maximum.*	

**whichever is greater*
***Rated sample is 1V DC across external current sampling resistor, with external current control.*

INPUT: 115±10V AC or 230±15V AC (selected) 50-65 cps, 1Ø. Size D has additional 104±9V AC and 208±18V AC inputs.
TEMPERATURE, AMBIENT OPERATING: –20°C to +50°C
TEMPERATURE, STORAGE: –40°C to +85°C
COOLING: Forced air, lateral circulation. Built-in blower.
ISOLATION VOLTAGE: 500 volts to chassis.
CONTROLS: Independent 10-turn controls for voltage and current. **Resolution:** 0.05%.
PROGRAMMING: 10 milliamperes control current, by resistance at 100 ohms per volt. May be operationally controlled as an amplifier, using voltage or current signals; common negative.
VOLTAGE RECOVERY, (for step load current): <50 microseconds.
AUTOMATIC CROSSOVER: Selects voltage regulation or current regulation operating mode automatically.
VIX® CIRCUIT: Mode indicators display operating condition, a ±8V, ±1 mA control signal is provided at rear terminals.

REMOTE ERROR SENSING: Compensates up to 0.5V drop per output lead.
OVERSHOOT: (Turn-on/off): None above 25% voltage setting; negligible below 25% when preloaded to 10% minimum.
SERIES/PARALLEL: Automatic crossover design permits self-determined parallel load sharing; also master/slave capability. Series operation to rated isolation.
METERS: Suffix "M" designates a pair of 2½" 2% meters. Delete suffix for unmetered unit.
TERMINALS: Binding posts on front panel, plus, minus and ground (except D size models). Sixteen (16) terminal barrier strip on rear contains output, sensing and control terminals. Separate heavy duty output terminals at the rear.
DIMENSIONS: See table for sizes. Removable side handles and skids included on D size.
FINISH: Per FED. STD. 595. Color 26440, (light gray).

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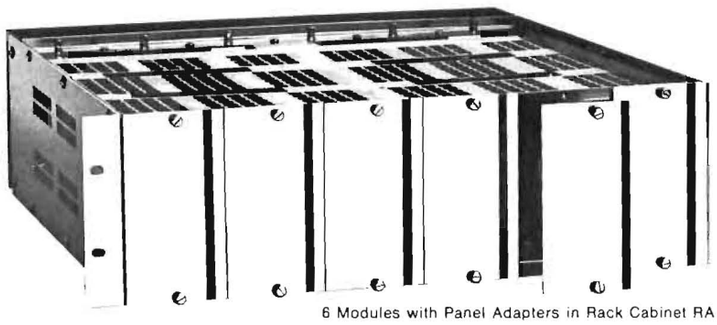
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OPS

OPERATIONAL

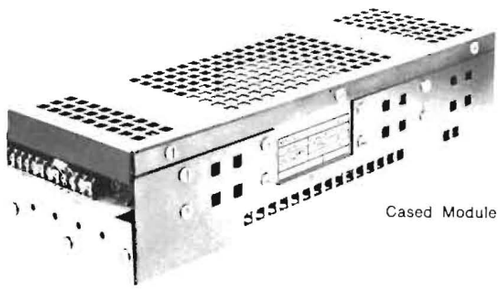
POWER SUPPLIES



6 Modules with Panel Adapters in Rack Cabinet RA 22-6

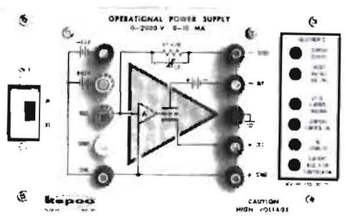
- *high gain dc amplifier*
- *high speed slewing*
- *offset voltage and current nulling*

MODEL	DC OUTPUT RANGE		OUTPUT IMPEDANCE		COMMON
	VOLTS	AMPS	OHMS DC	SOURCE INDUCTANCE	
OPS–1A	**0–20**	**0–0.05**	0.04	+15 μh	Minus
OPS 7–2	**0–7**	**0–2**	0.0005	+15 μh	Plus
OPS 15–1.5	**0–15**	**0–1.5**	0.001	+15 μh	Plus
OPS 21–1	**0–21**	**0–1**	0.0025	+15 μh	Plus
OPS 40–0.5	**0–40**	**0–0.5**	0.008	+15 μh	Plus
OPS 72–0.3	**0–72**	**0–0.3**	0.025	+15 μh	Plus
OPS 100–0.2	**0–100**	**0–0.2**	0.050	+15 μh	Plus
OPS– 2000	**0–2000**	**0–0.01**	20.0	+25 μh	Plus



Cased Module

SPECIFICATIONS	VOLTAGE AMPLIFIER OFFSETS**		OPS-2000 CURRENT MODE (Internal Sensing)	REFERENCE
	OFFSET VOLTAGE ΔE_{ib}	OFFSET CURRENT ΔI_{io}		+ 6.2V − 6.2V
LINE: 105-125/210-250V AC	<0.1 mV	<10 nA	<10 μA	<0.01%
LOAD: No load/full load	<1.0 mV	<10 nA	<10 μA	<0.001%
TIME: 8 hrs. (Stability)	<0.1 mV	<50 nA	<0.01%	<0.01%
TEMP.: Per °C (Coefficient)	<0.5 mV	<100 nA	<0.01%	<0.01%



Model OPS-2000

*whichever is greater

**E_{io} is the offset voltage and I_{io} is the offset current referred to the input of the voltage comparison amplifier.

DC VOLTAGE GAIN: More than 80 db.

OUTPUT SLEWING RATE: >500,000 volts/second [0.5V/μsec.] measured a. the chord to the first time constant on the exponential response. Model OPS-2000. >1,000,000 volts/second. [1V/μsec.].

SINUSOIDAL FREQUENCY RESPONSE: $f_{max.} = 160/E_{pp}$ kc. Model OPS-2000: Maximum frequency = $320/E_{pp}$ kc. (E_{pp} is the peak-to-peak voltage excursion.)

RIPPLE: >80 db below peak output or 3 mV rms, whichever is greater.

MAXIMUM CAPACITIVE LOADING: 0.001 microfarads. Excess capacitance slows response and causes peaking of response and instability. Adjustable lag networks provide for small range of load reactance.

TRANSIENT RESPONSE: Voltage Mode (for step load current) recovery is an exponential with 50 microsecond time constant. **Current Mode (for step load voltage)** recovery is at the rate of 0.5 volts per microsecond.

OFFSET NULLING: Fixed part of input offset voltage and input offset currents can be nulled.

REFERENCES: Two at +6.2V and −6.2V; maximum 1 milliampere.

PROGRAMMING: May be controlled by external voltage or current signals, common positive (OPS–1A common negative).

INPUT: 105-125V AC or 210-250V AC (selected), 50-440 cps single phase. Model OPS-2000: 50-65 cps single phase.

TEMPERATURE, AMBIENT OPERATING: −20°C to +60°C.

TEMPERATURE, STORAGE: −40°C to +85° C.

COOLING: Convection.

ISOLATION VOLTAGE: 500 volts to chassis.

CURRENT LIMITING: Adjustable from 10% to 110% of rated current. Model OPS-2000 is an automatic-crossover current regulator, see table for performance specifications.

TERMINALS: Connections via a rear mounted barrier strip. Plug-in Modules include a PC connector. Bench models have front panel terminal pattern (OPS 1A front terminals only).

DIMENSIONS: *Uncased:* 2½" H x 3 13/16" W x 12 13/16" D.
Cased: (Suffix C) 2 11/16" H x 4⅛" W x 13 3/16" D.
Models OPS-1A and OPS-2000 are available in bench style case only. OPS-1A: 4 1/16"H x 8 5/32"W x 5⅝"D.
OPS-2000: 5¼" H x 8 11/32" W x 17⅜" D.

FINISH: Modules–*Cases:* Royal blue epoxy.
Bench Style: OPS-1A–*Panel:* Brushed Aluminum.
OPS-2000, *Panel:* Per Fed. STD. 595. Color 26440, (light gray).
Bench Style Cases: Gray hammertone.

MOUNTING AND ACCESSORIES: See accessory pages for choice of mounting panels and housings. OPS-TA: equipped with plug-in slide guide and patch panel with adjustments. OPS-CCM: equipped with plug-in slide guide and current regulator controls, voltmeter and ammeter.

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PAR

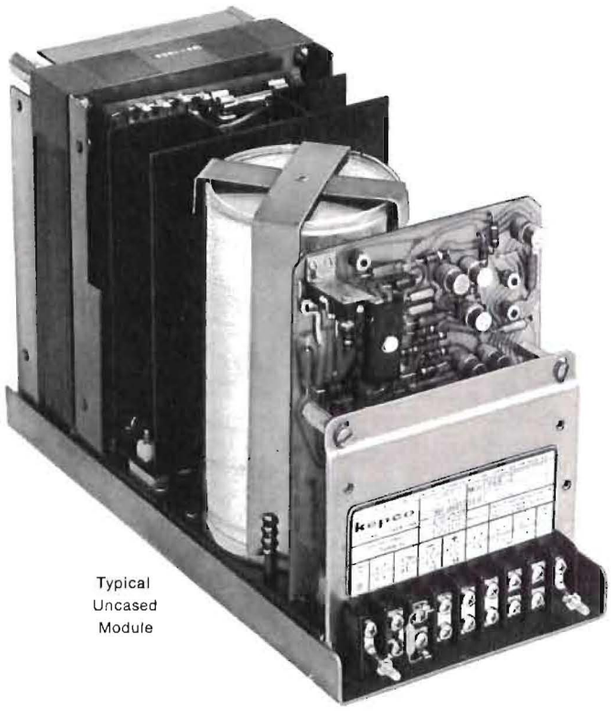
MODULAR

POWER SUPPLIES

- *overload current cutoff*
- *out-of-band programming*
- *precision regulator*
- *conventional transformer*

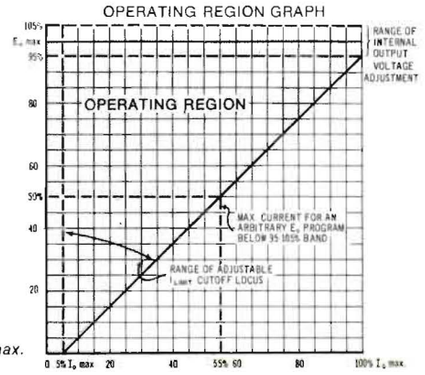
MODEL	OUTPUT† VOLTS	OUTPUT CURRENT at ambient temp 65°C †, 55°C ††	40°C †, 30°C ††	OUTPUT IMPEDANCE Ohms + Microhenries DC to 100 cps	100 cps to 1 kc	1 kc to 100 kc+μh
PAR–4	4±5%	0–9.0	0–11.0	0.0001	0.005	0.1+0.5
PAR–7	7±5%	0–8.0	0–10.0	0.0001	0.005	0.1+0.5
PAR–12	12±5%	0–5.5	0–7.0	0.0002	0.005	0.1+0.5
PAR–15	15±5%	0–4.6	0–6.0	0.0003	0.005	0.1+0.5
PAR–24	24±5%	0–3.4	0–4.0	0.0006	0.005	0.1+0.5
PAR–28	28±5%	0–3.1	0–3.7	0.0008	0.005	0.1+0.5
PAR–36	36±5%	0–2.3	0–2.8	0.0015	0.005	0.1+0.5
PAR–48	48±5%	0–1.8	0–2.3	0.0022	0.005	0.1+0.5
PAR–60	60±5%	0–1.5	0–2.0	0.003	0.005	0.1+0.5

†Uncased: ††Cased



Typical Uncased Module

OPERATING REGION GRAPH



SPECIFICATION	VOLTAGE MODE	CURRENT MODE** (External Sensing)
OUTPUT RANGE	±5% †	1 mA to I_{limit} cutoff locus
REGULATION, LINE	<0.005%	<0.005% at rated sample**
REGULATION, LOAD	<0.01% or 0.5 mV*	<0.01% at rated sample** ‡
STABILITY (8 HR.)	<0.02% or 2 mV*	<0.02% or 1 mA
TEMP. COEFFICIENT	<0.02% per °C	<0.02% per °C at rated sample**
RIPPLE, rms	<0.25 mV	<0.01% of I_O max.

*whichever is greater
**Rated sample is 1 volt across external current sensing resistor with external current control.
†Adjustable to zero with corresponding current derating (see operating region graph).
‡The compliance voltage range lies within shaded operating region from the I_{limit} locus to 105% E_O max.

INPUT: 105-125V AC or 210-250V AC, (selected), 50-440 cps single phase; approximately 2 amperes, 200 watts.

TEMPERATURE, AMBIENT OPERATING: *Uncased:* −20°C to + 65°C maximum (see rating chart). *Cased:* −20°C to +55°C maximum (see rating chart).

TEMPERATURE, STORAGE: −40°C to +85°C.

COOLING: Convection.

ISOLATION VOLTAGE: 500 volts to chassis.

CONTROL/PROGRAMMING: ±5% internal trimmer (voltage or current). External resistance programming ratio is 1000 ohms per volt. A 1% fixed resistor is supplied to program the tabulated nominal voltage. When programmed below the ±5% output band, derate current per operating region graph.

VOLTAGE RECOVERY, (for step load current): <50 μseconds.

OVERLOAD CURRENT CUTOFF: Adjustable cutoff locus pivots about the $E_O \approx 0$, $I_O \approx 5\%$ point, reducing the output current into an overload. *Note:* Nonlinear loads drawing a high starting current may be locked out by the cutoff locus, and require a starting resistance to be contained within the shaded regions of the operating region graph.

REMOTE ERROR SENSING: Compensates for up to 0.5 volt drop per output lead.

OVERSHOOT: (Turn-off): None in ±5% operating band. When output is set below 25%, load to approximately 10% for negligible overshoot.

SERIES/PARALLEL: Connections are provided for parallel operation of identical units. Series operation to rated isolation.

OVERVOLTAGE PROTECTOR: Provision is made for attachment of an optional crowbar overvoltage protector, type VP-PAR. See accessory listing for detailed description of protector.

TERMINALS: All input, output, sense and control connections are made via a single multiterminal barrier strip.

DIMENSIONS: *Uncased:* 6¾"H x 4¾" W x 10⅜"D.
Cased: 6⅛"H x 5"W x 10⅞"D.

FINISH: *Case:* Royal Blue epoxy.

MOUNTING: Rack mounting panel adapters available. See accessory pages.

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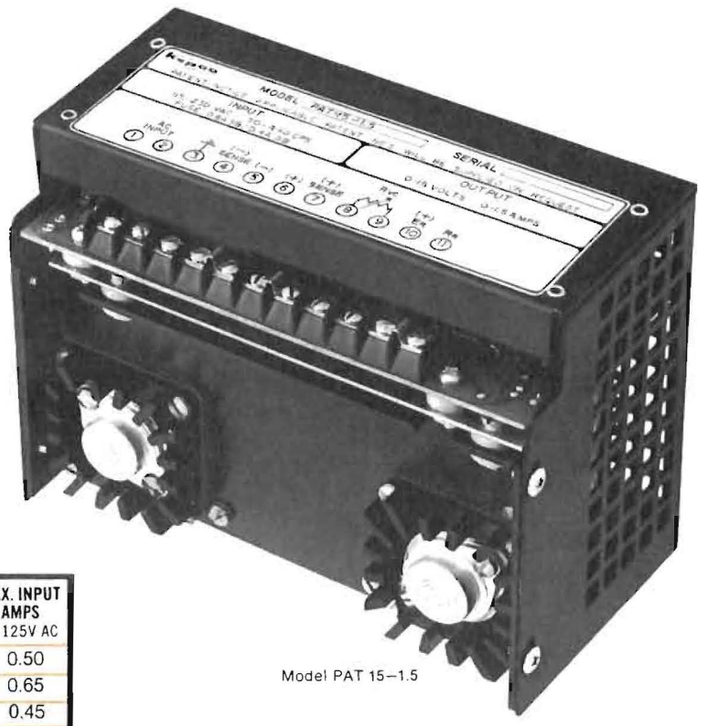
KEPCO

PAT

MODULAR

POWER SUPPLIES

- *voltage/current regulation*
- *full range operationally programmable*
- *all silicon design*

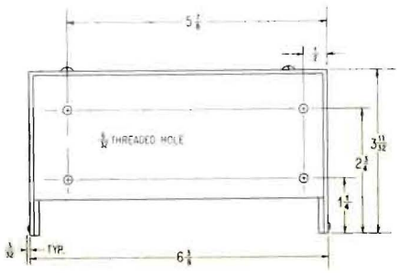


Model PAT 15–1.5

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	OUTPUT IMPEDANCE Ohms + Microhenries DC-100cps	0.1-1kc	1-100kc	MAX. INPUT AMPS at 125V AC
PAT 7–2	**0–7**	**0–2**	0.0005	0.02	0.1+1	0.50
PAT 15–1.5	**0–15**	**0–1.5**	0.001	0.02	0.1+1	0.65
PAT 21–1	**0–21**	**0–1**	0.0025	0.02	0.1+1	0.45
PAT 40–0.5	**0–40**	**0–0.5**	0.008	0.02	0.1+1	0.40
PAT 72–0.3	**0–72**	**0–0.3**	0.025	0.02	0.1+1	0.45
PAT 100–0.2	**0–100**	**0–0.2**	0.050	0.02	0.1+1	0.45

SPECIFICATIONS	VOLTAGE MODE	CURRENT MODE** (External Sensing)
OUTPUT RANGE	0–100% E_O max.	1mA–100% I_O max.
REGULATION, LINE	<0.01%	<0.01% at rated sample**
REGULATION, LOAD	<0.01% or 1 mV*	<0.02% at rated sample**
STABILITY (8 HR.)	<0.01% or 2 mV*	<0.05% or 1 mA*
TEMP. COEFFICIENT	<0.01% per °C	<0.05% per °C
RIPPLE, rms.	<0.1 mV	<0.02% of I_O max.

*whichever is greater
**Rated sample is 1V DC across external current sampling resistor with external current control.



MOUNTING DIMENSIONS

INPUT: 105-125V AC or 210-250V AC (selected), 50-440 cps single phase.

TEMPERATURE, AMBIENT OPERATING: Cased: –20°C to +71°C.

TEMPERATURE, STORAGE: –40°C to +85°C.

COOLING: Convection.

ISOLATION VOLTAGE: 500 volts to chassis.

PROGRAMMING: Approximately 1 mA control current, externally adjustable by resistance at ≅1000 ohms per volt. Specify suffix "R" to obtain model with integral ±10% control current adjustment. May be operationally controlled as an amplifier using voltage or current signals; common positive.

VOLTAGE RECOVERY, (for step load current): <50 μseconds.

CURRENT LIMITING: Adjustable from 10% to 105% of rated full current.

REMOTE ERROR SENSING: Compensates up to 0.5 volt drop per output lead.

OVERSHOOT: (Turn-on/off): None above 25% voltage setting; negligible below 25% when preloaded to 10% minimum.

SERIES/PARALLEL: Series operation to rated isolation; also master/slave capability. Current limiting design permits self-determined parallel load sharing.

TERMINALS: All input, output and control connections are made via a multi-terminal barrier strip.

DIMENSIONS: Cased: 3 11/32"H x 6 1/8"W x 4 29/32"D.

FINISH: Black anodized aluminum.

MOUNTING: Rack Adapters available, see accessory pages.

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

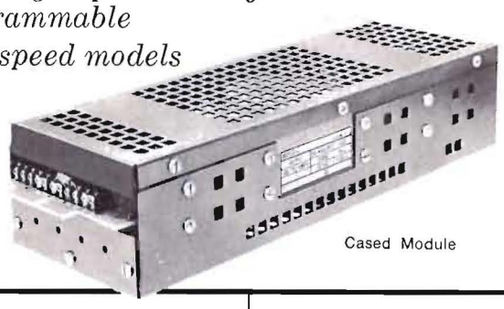
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MODULAR
POWER SUPPLIES

- *voltage/current regulation*
- *full range operationally programmable*
- *high speed models*



Cased Module



6 Modules with Panel Adapters in Rack Cabinet RA 22–6

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	OUTPUT IMPEDANCE Ohms + Microhenries DC to 100 cps	100 cps to 1 kc	1 kc to 100 kc+μh	MAX. INPUT AMPS at 125 V AC
PAX 7–1	**0–7**	**0–1**	0.004	0.02	0.1+**1**	0.3
PAX 7–1HS	**0–7**	**0–1**	0.004	0.2	0.2+15	0.3
PAX 15–0.75	**0–15**	**0–0.75**	0.010	0.02	0.1+1	0.3
PAX 15–0.75HS	**0–15**	**0–0.75**	0.010	0.2	0.2+15	0.3
PAX 21–0.5	**0–21**	**0–0.5**	0.025	0.02	0.1+1	0.3
PAX 21–0.5HS	**0–21**	**0–0.5**	0.025	0.2	0.2+15	0.3
PAX 36–0.3	**0–36**	**0–0.3**	0.06	0.02	0.1+1	0.3
PAX 36–0.3HS	**0–36**	**0–0.3**	0.06	0.2	0.2+15	0.3
PAX 72–0.15	**0–72**	**0–0.15**	0.25	0.02	0.1+1	0.3
PAX 72–0.15HS	**0–72**	**0–0.15**	0.25	0.2	0.2+15	0.3
PAX 100–0.1	**0–100**	**0–0.1**	0.5	0.02	0.1+1	0.3
PAX 100–0.1HS	**0–100**	**0–0.1**	0.5	0.2	0.2+15	0.3

SPECIFICATION	VOLTAGE MODE	CURRENT MODE** (External Sensing)
OUTPUT RANGE	0–100% E_O max.	1 mA to 100% I_O
REGULATION, LINE	<0.05% or 1 mV*	<0.1% at rated sample**
REGULATION, LOAD	<0.05% or 1 mV*	<0.1% at rated sample**
STABILITY (8 HR.)	<0.05% or 3 mV*	<0.1% or 1 mA*
TEMP. COEFFICIENT	<0.05% per °C	<0.1% per °C at rated sample**
RIPPLE, (Standard Speed)	<0.25 mV, rms.	<0.1% I_O max.
RIPPLE, (High Speed)	<60 db below peak output (grounded)	<60 db below peak output (grounded)

**whichever is greater*

***Rated sample is 1V DC across external current sampling resistor, with external current control.*

INPUT: 105-125V AC or 210-250V AC (selected), 50-440 cps single phase.

TEMPERATURE, AMBIENT OPERATING: –20°C to +50°C.

TEMPERATURE, STORAGE: –40°C to +85°C.

COOLING: Convection.

ISOLATION VOLTAGE: 500 volts to chassis.

PROGRAMMING: Approximately 1mA control current. Externally adjustable, by resistance at ≈1000 ohms per volt. Specify suffix "R" to obtain model with integral ±10% control current adjustment. May be operationally controlled as an amplifer using voltage or current signals; common negative.

VOLTAGE RECOVERY: (for step load current): <50 microseconds.

CURRENT LIMITING: Adjustable from 25% to 150% of rated full current.

REMOTE ERROR SENSING: Compensates up to 0.5V drop per output lead.

OVERSHOOT: (Turn-on/off): None above 25% voltage setting; negligible below 25% when preloaded to 10% minimum.

HIGH SPEED MODELS, (Suffix HS):

Slewing: >50,000 volts per second, measured as the chord to the first time constant on the exponential response.

Sinusoidal Frequency Response: $f_{max} = \frac{16}{E_{pp}}$ kc

(E_{pp} is the peak-to-peak voltage excursion.)

Maximum Capacitive Loading: 0.001 microfarad.

Transient Response:

Voltage Mode: To a step load current, excursion is $L\frac{di}{dt}$ (see impedance table for value of "L"). Recovery is an exponential with a 50 microsecond time constant.

Current Mode: To a step load voltage, recovery is at the rate of 20 volts per millisecond.

SERIES/PARALLEL: Series operation to rated isolation; also master/slave capability. Current limiting design permits self-determined parallel load sharing.

TERMINALS: All input, output and control connections are made via a multi-terminal barrier strip and printed circuit connector.

DIMENSIONS: *Uncased:* 2½"H x 3⅜"W x 12⅞"D.
Cased: (Suffix C) 2⅞"H x 4⅛"W x 13⅜"D.

FINISH: Blue anodized aluminum. Panel adapter BPA-22 finished per FED. STD. 595, Color 26440, (light gray).

MOUNTING: See Accessory page for choice of mounting panels and housings.

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

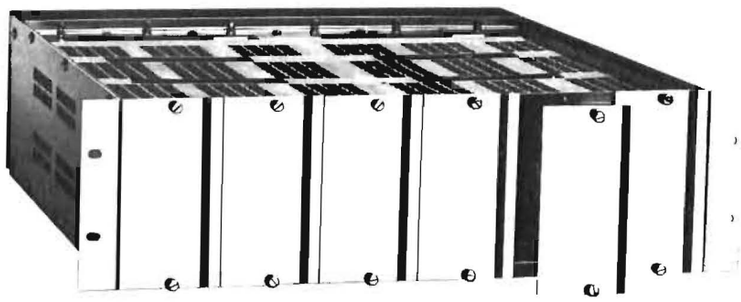
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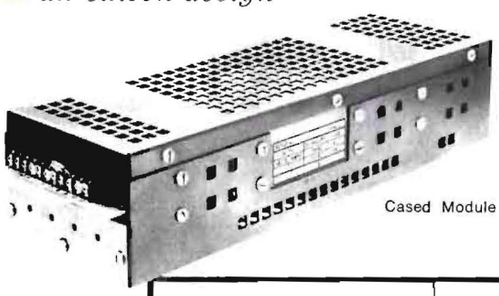
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MODULAR
POWER SUPPLIES

- *voltage/current regulation*
- *full range operationally programmable*
- *all silicon design*



6 Modules with Panel Adapters in Rack Cabinet RA 22–6



Cased Module

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	OUTPUT IMPEDANCE Ohms + Microhenries DC to 100 cps	100 cps to 1kc	1 kc to 100 kc+μh	MAX. INPUT AMPS at 125V AC
PBX 7–2	**0–7**	**0–2**	0.0004	0.02	0.1+1μh	0.50
PBX 15–1.5	**0–15**	**0–1.5**	0.001	0.02	0.1+1μh	0.65
PBX 21–1	**0–21**	**0–1**	0.0025	0.02	0.1+1μh	0.45
PBX 40–0.5	**0–40**	**0–0.5**	0.008	0.02	0.1+1μh	0.40
PBX 72–0.3	**0–72**	**0–0.3**	0.025	0.02	0.1+1μh	0.45
PBX 100–0.2	**0–100**	**0–0.2**	0.050	0.02	0.1+1μh	0.45

SPECIFICATION	VOLTAGE MODE	CURRENT MODE** (External Sensing)
OUTPUT RANGE	0–100% E_O	1 mA–100% I_O
REGULATION, LINE	<0.01%	<0.01% at rated sample**
REGULATION, LOAD	<0.01% or 1 mV*	<0.01% at rated sample**
STABILITY (8 HR.)	<0.01% or 2 mV*	<0.05% or 1 mA*
TEMP. COEFFICIENT	<0.01% per °C	<0.05% per °C at rated sample**
RIPPLE, rms.	<0.1 mV	<0.02% I_O max.

**whichever is greater*
***rated sample is 1V DC across external current sampling resistor, with external current control.*

INPUT: 105-125V AC or 210-250V AC (selected), 50-440 cps single phase.

TEMPERATURE, AMBIENT OPERATING: Cased: –20°C to +65°C. Uncased: –20°C to +71°C.

TEMPERATURE: STORAGE: –40°C to +85°C.

ISOLATION VOLTAGE: 500 volts to chassis.

PROGRAMMING: Approximately 1mA control current. Externally adjustable, by resistance at ≈1000 ohms per volt. Specify suffix "R" to obtain model with integral ±10% control current adjustment. May be operationally controlled as an amplifier using voltage or current signals; common positive.

VOLTAGE RECOVERY: (for step load current): <50 μseconds.

CURRENT LIMITING: Adjustable from 10% to 105% of rated full current.

REMOTE ERROR SENSING: Compensates up to 0.5 volt drop per output lead.

OVERSHOOT: (Turn-on/off): None above 25% voltage setting; negligible below 25% when preloaded to 10% minimum.

SERIES/PARALLEL: Series operation to rated isolation; also master/slave capability. Current limiting design permits self-determined parallel load sharing.

COOLING: Convection.

TERMINALS: All input, output and control connections are made via a multi-terminal barrier strip and printed circuit connector.

DIMENSIONS: *Uncased:* 2½"H x 3⅜"W x 12⅜"D.
Cased: (Suffix C) 2⅛"H x 4⅛"W x 13⅜"D.

FINISH: Blue anodized aluminum. Panel adapter BPA-22 finished per FED. STD. 595, Color 26440, (light gray).

MOUNTING: See Accessory page for choice of mounting panels and housings. Metered panels (suffix MAT) available, see PBX-MAT Catalog page.

All terms used in the specifications are defined in the Kepco Glossary on Page 33

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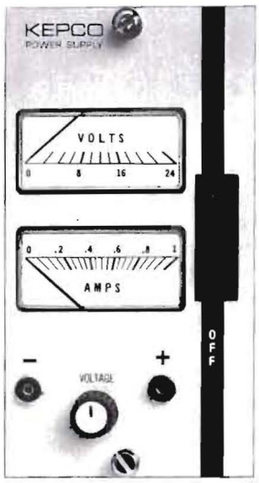
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PBX-MAT AND OPS-TA

MODULAR

POWER SUPPLIES

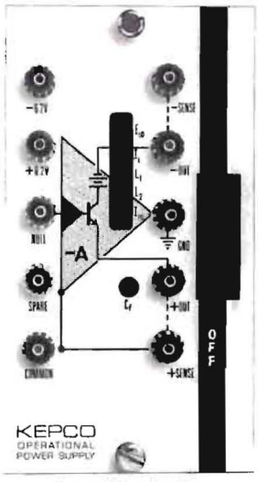


Model PBX 21-1MAT Panel

The MAT attachment to Kepco's PBX models provides **meters** (two, for voltage and current; **adjustment,** (a multi-turn voltage control); and **terminals** (pin jacks).



Six slot rack mountable housing – Model RA 22-6



Model OPS 40-0.5TA Panel

The TA attachment to Kepco's OPS models provides **terminals** (a 10-jack patch panel) and **adjustments** (offset nulling, AC lags and current limiting).

MODEL	DC OUTPUT RANGE VOLTS	AMPS	MAX. INPUT AMPS at 125V AC
PBX 7–2MAT	**0–7**	**0–2**	0.50
PBX 15–1.5MAT	**0–15**	**0–1.5**	0.65
PBX 21–1MAT	**0–21**	**0–1**	0.45
PBX 40–0.5MAT	**0–40**	**0–0.5**	0.40
PBX 72–0.3MAT	**0–72**	**0–0.3**	0.45
PBX 100–0.2MAT	**0–100**	**0–0.2**	0.45

MODEL	DC OUTPUT RANGE VOLTS	AMPS	MAX. INPUT AMPS at 125V AC
OPS 7–2TA	**0–7**	**0–2**	0.50
OPS 15–1.5TA	**0–15**	**0–1.5**	0.65
OPS 21–1TA	**0–21**	**0–1**	0.45
OPS 40–0.5TA	**0–40**	**0–0.5**	0.40
OPS 72–0.3TA	**0–72**	**0–0.3**	0.45
OPS 100–0.2TA	**0–100**	**0–0.2**	0.45

SPECIFICATIONS: Same as for regular PBX and OPS models; see specifications pages.

HARDWARE, ADAPTERS and ACCESSORY ITEMS

Panels finished per Fed. STD. 595, Color 26440 (light gray).
Cases: Gray Hammertone.

	DIMENSIONS H	W	D
PBX-MAT (Assembly)	5 7/32"	x 2 25/32"	x 15"
OPS-TA (Assembly)	5 7/32"	x 2 25/32"	x 15"

RACK CABINET:

RA 22-6—Six slot housing w/o plug board*	5 7/32"	x 19"	x 16 3/8"
BPA-22—Blank panel assy. w/ slide plate	5 7/32"	x 2 25/32"	x 14 5/8"

ADAPTER:

PC-1 Connector, for use with uncased models.			
PC-2—Plug-in adapter*	5 7/32"	x 2 1/32"	—

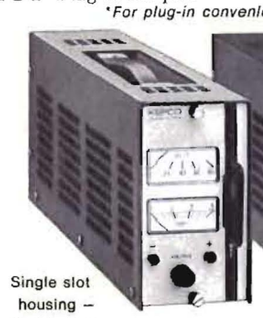
**For plug-in convenience in the RA-22-6, use (1) PC-2 per slot.*

FILLER PANELS:

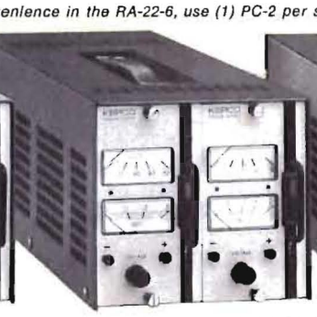
	DIMENSIONS H	W	D
RFP 22-1—Single filler panel for RA 22-6	5 7/32"	x 2 25/32"	—
RFP 22-2—Double filler panel for RA 22-6	5 7/32"	x 5 3/16"	—
RFP 22-3—Triple filler panel for RA 22-6	5 7/32"	x 3 3/8"	—

CASES:

CA-3—Single slot housing w/ plug board	5 7/32"	x 2 25/32"	x 16"
CA-4—Double slot housing w/ plug board	5 7/32"	x 5 3/16"	x 16"
CA-5—Triple slot housing w/ plug board	5 7/32"	x 8 3/8"	x 16"



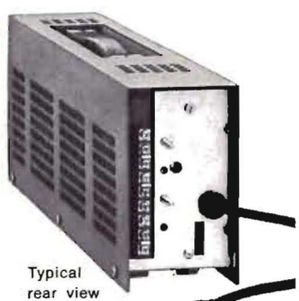
Single slot housing – Model CA-3



Dual slot housing – Model CA-4



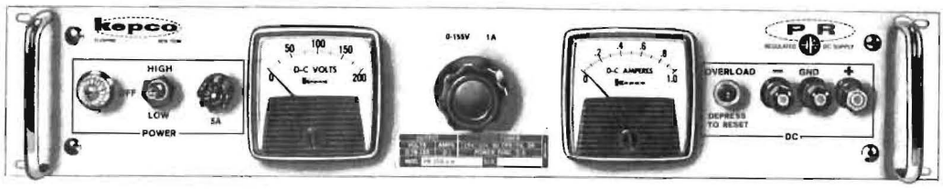
Triple slot housing – Model CA-5



Typical rear view

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Model PR 155–1M

KEPCO

PR

RESONANT TRANSFORMER

POWER SUPPLIES

- *constant voltage transformer*
- *adjustable output*

GROUP I

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	RIPPLE (MAX.) RMS %	OUTPUT IMPEDANCE Ohms + μh 1 kc to 10 kc	OUTPUT IMPEDANCE Ohms + μh 10 kc to 100 kc +μh	DIMENSIONS H	DIMENSIONS W	DIMENSIONS D	MAX. INPUT AMPS at 125 V AC
PR 15–10M	0-7.5-15	0-10	2	0.02	0.04+0.1	3½"	19"	13⅞"	3.5
PR 15–30M	0-15	0-30	2	0.02	0.04+0.1	7"	19"	13⅞"	7.0
PR 38–5M	0-19-38	0-5	1	0.03	0.04+0.1	3½"	19"	13⅞"	4.0
PR 38–15M	0-38	0-15	1	0.03	0.04+0.2	7"	19"	13⅞"	9.0
PR 80–2.5M	0-40-80	0-2.5	0.7	0.04	0.04+0.1	3½"	19"	13⅞"	4.0
PR 80–8M	0-80	0-8	0.7	0.05	0.07+0.5	7"	19"	13⅞"	9.5
PR 155–1M	0-78-155	0-1	0.6	0.1	0.1 +0.1	3½"	19"	13⅞"	3.0
PR 155–4M	0-155	0-4	0.6	0.1	0.1 +0.5	7"	19"	13⅞"	9.0
PR 220–3M	0-220	0-3	0.5	0.2	0.1 +0.5	7"	19"	13⅞"	9.0
PR 310–0.6M	0-165-310	0-0.6	0.5	0.3	0.1 +0.1	3½"	19"	13⅞"	3.0
PR 310–2M	0-310	0-2	0.5	0.3	0.1 +0.5	7"	19"	13⅞"	9.0

GROUP II

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	RIPPLE (MAX.) RMS %	OUTPUT IMPEDANCE Ohms + μh 1 kc to 10 kc	OUTPUT IMPEDANCE Ohms + μh 10 kc to 100 kc +μh	DIMENSIONS H	DIMENSIONS W	DIMENSIONS D	MAX. INPUT AMPS at 230 V AC
PR 20–100AM	0-20	0-100	3	0.05	0.06+0.1	8¾"	19"	20"	9.0/ø
PR 40–50AM	0-40	0-50	2	0.05	0.06+0.1	8¾"	19"	20"	8.5/ø
PR 50–40AM	0-50	0-40	1.5	0.05	0.06+0.1	8¾"	19"	20"	8.5/ø

FIGURE 1

LINE REGULATION: ±1% for 115V AC ±10V *Group I*
(See Figure 4) ±2% for 115V AC ±10V *Group II*

LOAD REGULATION: 2% for half to full load except 5% for 15V and 20V models. 4% for quarter to full load except 8% for 15V and 20V models.
(See Figure 3)

STABILITY: (8 HRS.): 1% or 0.1V, whichever is greater.

TEMPERATURE COEFFICIENT: 0.05% per °C

AMBIENT OPERATING TEMPERATURE: –20°C to +55°C.

STORAGE TEMPERATURE: –40°C to +85°C.

COOLING: Forced air lateral circulation; built-in blower.

INPUT: *Group I:* 115 ±10V AC, 60 cps ±5% single phase. *Group II:* 208 or 230V AC (selectable) ±10%, 60 cps, ±5% three phase.

Overseas Units: Specify suffix "–50" for selectable 104 ±9V AC; 115 ±10V AC; 208 ±18V AC; 230 ±20V AC, 50 cps ±5%. Group II models with –50 suffix have 208 or 230V AC input options only. Derate *output voltage* range by 20% when ordering with –50 option.
NOTE: A 1% line frequency change will produce approximately 1% output voltage change.

ISOLATION VOLTAGE: 600 volts to chassis.

CONTROL RESOLUTION: Approximately 1%. *Range:* 0.2% to 100% E_O max. (in two ranges on 3½" high models of Group I).

VOLTAGE RECOVERY (50-100% current): <400 milliseconds.

SERIES/PARALLEL: Units can be paralleled by adjusting their outputs to share the load. Series operation to rated isolation.

OVERLOAD PROTECTION: Constant voltage transformer limits current at maximum voltage setting; circuit breaker protection at lower settings.

OVERSHOOT: (Turn-on/off): None above 25% voltage setting; negligible below 25% when preloaded 10% minimum.

METERS: Suffix "M" designates a pair of 2½", 2% meters. Delete suffix for unmetered unit.

TERMINALS: Binding posts on front panel, plus, minus and ground (except Group II models which have a heavy duty output connector at the rear.

DIMENSIONS: See table for sizes. Removable handles and skids included on Group II models.

FINISH: Per FED. STD. 595. Color 26440, (light gray).

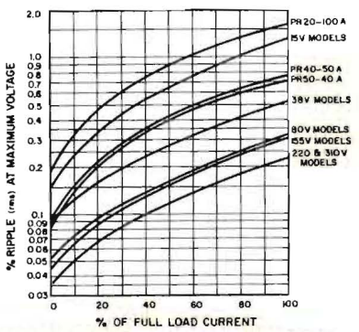


FIGURE 2: TYPICAL RIPPLE CHARACTERISTICS AS A FUNCTION OF LOAD CURRENT

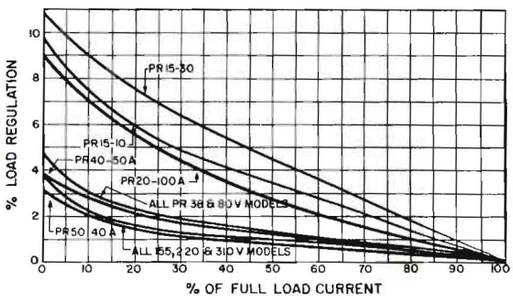


FIGURE 3: TYPICAL LOAD REGULATION
MEASURED AT MAXIMUM RATED OUTPUT VOLTAGE; NORMAL LINE

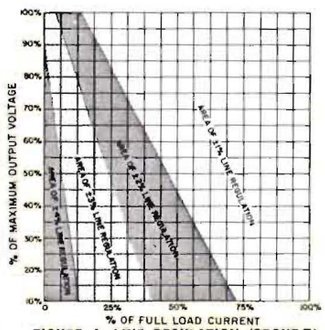


FIGURE 4: LINE REGULATION (GROUP I) AS A FUNCTION OF OUTPUT VOLTAGE AND LINE CURRENT

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

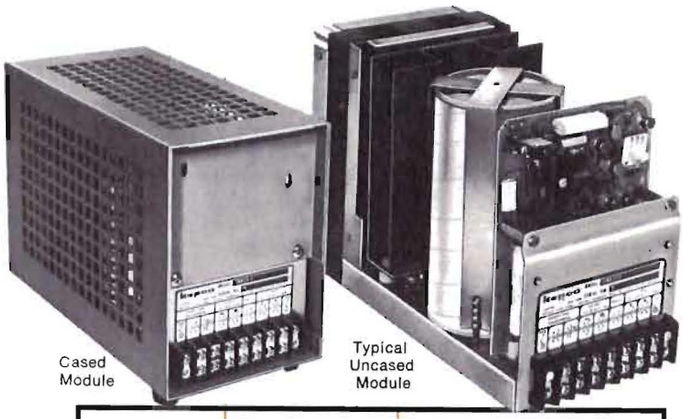
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KEPCO
PWR
MODULAR
POWER SUPPLIES

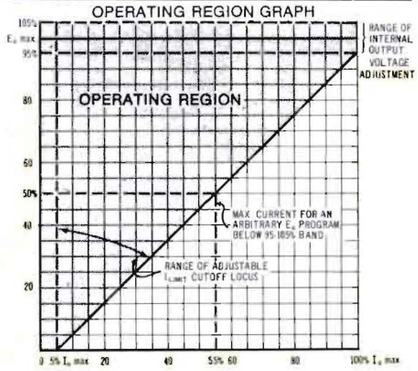
- *overload current cutoff*
- *out-of-band programming*
- *precision regulator*
- *flux oscillating transformer*



MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	OUTPUT IMPEDANCE Ohms + Microhenries DC to 100 cps	100 cps to 1 kc	1 kc to 100 kc + μh
PWR 4–14	4±5%	0–14	0.0002	0.005	0.1+0.5
PWR 7–11	7±5%	0–11	0.0003	0.005	0.1+0.5
PWR 12–7	12±5%	0–7	0.001	0.005	0.1+0.5
PWR 15–6	15±5%	0–6	0.002	0.005	0.1+0.5
PWR 24–4	24±5%	0–4	0.003	0.005	0.1+0.5
PWR 28–3.3	28±5%	0–3.3	0.004	0.005	0.1+0.5
PWR 36–3	36±5%	0–3	0.006	0.005	0.1+0.5
PWR 48–2	48±5%	0–2	0.015	0.005	0.1+0.5
PWR 60–1.5	60±5%	0–1.5	0.02	0.005	0.1+0.5

SPECIFICATION	VOLTAGE MODE	CURRENT MODE** (External Sensing)
OUTPUT RANGE	±5% E_O†	1mA to I_{limit} cutoff locus
REGULATION, LINE	<0.005%	<0.05% at rated sample**‡
REGULATION, LOAD	<0.05% or 1 mV*	<0.1% at rated sample**
STABILITY (8 HR.)	<0.05% or 3 mV*	<0.1% or 1 mA
TEMP. COEFFICIENT	<0.05% per °C	<0.1% per °C at rated sample**
RIPPLE, rms.	<0.25 mV	<0.1% of I_O max.

OPERATING REGION GRAPH



*whichever is greater
**Rated sample is 1 volt across external current sampling resistor with external current control.
†Adjustable to zero with corresponding current derating (see operating region graph).
‡Compliance voltage range lies within shaded operating region from limit locus to 105% E_O max.

INPUT: 100-130V AC, 60 cps ±1 cps single phase; approximately 2 amperes, 200 watts.

Overseas Units: Specify suffix "–50" for selectable 104 ±13.5V AC, 115 ±15V AC, 208 ±27V AC, or 230 ±30 V AC, 50 cps ±1 cps. Derate output current by 20% when ordering with "–50" option.

TEMPERATURE AMBIENT OPERATING: *Uncased:* –20°C to +65°C. *Cased:* –20° to +55°C.

TEMPERATURE, STORAGE: –40°C to +85°C.

COOLING: Convection.

ISOLATION VOLTAGE: 500 volts to chassis.

CONTROL/PROGRAMMING: ±5% by internal trimmer for voltage or current. External resistance programming ratio is 1000 ohms per volt, 1 mA control current. A 1% fixed resistor is supplied to program the tabulated nominal voltage. When programmed below ±5% output band, derate current per operating region graph.

VOLTAGE RECOVERY: (for step load current): <50 microseconds.

OVERLOAD CURRENT CUTOFF: Adjustable cutoff locus pivots about the $E_O \approx 0$, $I_O \approx 5\%$ point, reduces current into an overload. *Note:* Non-linear loads drawing a high starting current may be locked out by the cutoff locus, and require a starting resistance to be contained within the shaded regions of the operating region graph.

REMOTE ERROR SENSING: Compensates for up to 0.5 volt drop per output lead.

OVERSHOOT: (Turn-on/off): None in ±5% operating band. When output is set below 25%, load to approximately 10% to maintain negligible overshoot.

SERIES/PARALLEL: Connections are provided for parallel operation of identical units. Series operation to rated isolation.

TERMINALS: All input, output, sense and control connections are made via a single multiterminal barrier strip.

DIMENSIONS: *Uncased:* 6¾"H x 4¾" W x 10⅜"D.
Cased: 6⅝"H x 5"W x 10⅞"D.

FINISH: *Case:* Royal Blue epoxy.

MOUNTING: Rack Adapters available, see accessory page.

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

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PATENT NOTICE: Applicable Patent Nos. will be supplied on request.

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KEPCO

PRM

MODULAR

POWER SUPPLIES

- *fixed voltage*
- *economical*
- *high reliabilty*

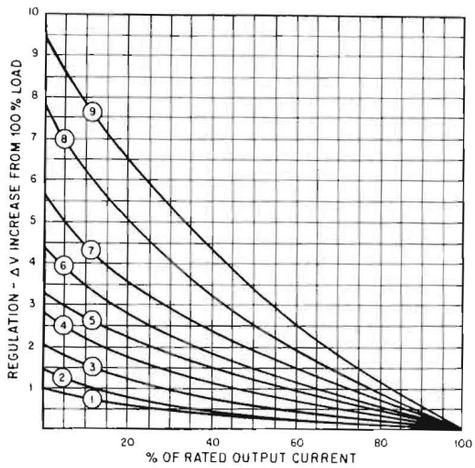


FIGURE 1: TYPICAL LOAD REGULATION FOR ALL PRM MODELS

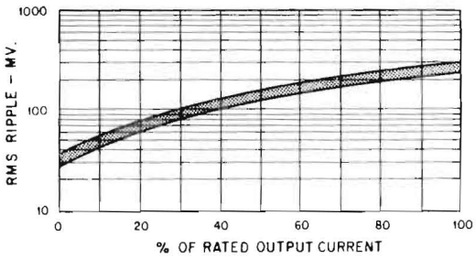


FIGURE 2: TYPICAL RIPPLE AS A FUNCTION OF LOAD FOR ALL PRM MODELS EXCEPT EXTRA FILTERED MODELS

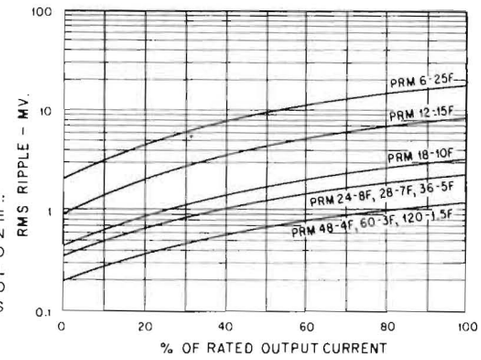


FIGURE 3: TYPICAL RIPPLE AS A FUNCTION OF LOAD FOR ALL EXTRA FILTERED MODELS

SPECIFICATION	SIZE A 180 SERIES	SIZE B 120 SERIES	SIZE C 180F (EXTRA FILTERED SERIES)	SIZE C 300 (DUAL 150 SERIES)
ACCURACY*	± 2%	± 2%	±2%**	2%†
REGULATION, LINE	±1%‡	±1%‡	±1%‡	±1%▼
STABILITY (8 hr.)	1% or 0.1V	1% or 0.1V	1% or 0.1V	1% or 0.1V
TEMP. COEFFICIENT	0.05% per °C	0.05% per °C	0.05% per °C	0.05% per °C
INPUT (115V AC, 60 cps)	3A (280w)	2A (190w)	3A (280w)	5A (465w)

**At 115V AC, full load, 30°C. Initial (cold) output is 1% higher.*
***The filter introduces an added 2% drop, a 10% reduction in load current will compensate for the loss.*
†Interaction is less than 2% as the other supply in the dual package is loaded from zero to maximum.
‡For ±15V AC line variation, at 25-100% load. For loads below 25%, line regulation is ±1.5% output change.
▼For ±15V AC line variation, at 50-100% load. For loads below 50%, line regulation is ±1.5% output change.

INPUT: 115V AC ± 15 V AC, 60 cps ±5% single phase.

Overseas Models: For 50 cps ±5% specify suffix "–50". Inputs: (selectable) 104 ±13.5V AC, 115V AC, 208 ±27V AC or 230 ±30V AC. Output *current* rating is derated 20% in 50 cps version.

NOTE: Input frequency variations produces an approximate equal percentage output voltage change.

TEMPERATURE, AMBIENT OPERATING: –20°C to +55°C

TEMPERATURE STORAGE: –40°C to +85°C

COOLING: Convection.

OUTPUT IMPEDANCE: 1 kc – 10 kc: 0.05 ohms, 10 kc – 100 kc: 0.05 ohms + 0.5 microhenries. Below 1000 cps impedance is a function of a load current and may be derived from the slope of load regulation curve $\Delta E/\Delta I$.

VOLTAGE RECOVERY: (50-100% current): <400 milliseconds.

OVERLOAD PROTECTION: Current limiting transformer restricts short circuit current to safe value. A thermal circuit breaker is employed in *dual* models.

ISOLATION VOLTAGE: 600 volts to chassis (or between the outputs of dual models.

SERIES/PARALLEL OPERATION: Identical models, or halves of a dual supply can be paralled for approximately double current (allow for 10% imbalance). Series operation to rated isolation.

ACCESSORIES: Various rack adapters available, see accessory page. *Cases:* Size A uses CA-200
Size C uses CA-300
Size B has non-removable integral enclosure.
Add suffix "C" for cased Size A & C models.

FINISH: *Cases:* royal blue.

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

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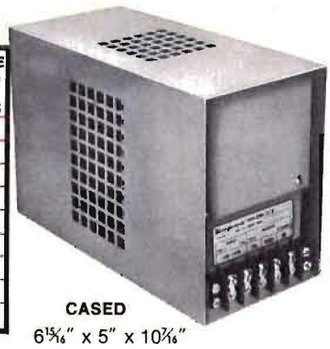
SIZE "A" - 180 SERIES



UNCASED
6¾" x 4¾" x 10⅜"

MODEL	DC OUTPUT VOLTS	DC OUTPUT AMPS	LOAD REGULATION* ΔV INCREASE 100%-50% LOAD	LOAD REGULATION* ΔV INCREASE 100%-25% LOAD	LOAD REG. CURVE (Fig. 1)	RIPPLE (MAX) RMS VOLTS
PRM 6–25	6.3	0–25	0.5	0.8	1	0.4
PRM 12–15	12	0–15	0.6	1.0	1	0.4
PRM 18–10	18	0–10	0.6	1.0	2	0.3
PRM 24–8	24	0–8	0.7	1.2	2	0.3
PRM 28–7	28	0–7	0.7	1.2	2	0.4
PRM 36–5	36	0–5	0.8	1.3	3	0.4
PRM 48–4	48	0–4	1.0	1.8	4	0.3
PRM 60–3	60	0–3	1.1	1.9	5	0.3
PRM 120–1.5	120	0–1.5	2.2	3.6	7	0.3

*Measured at 115V AC Line.



CASED
6¹⁵⁄₁₆" x 5" x 10⁷⁄₁₆"

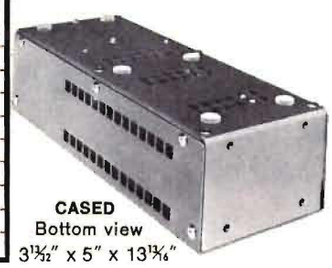
SIZE "B" - 120 SERIES



Available
cased only

MODEL	DC OUTPUT VOLTS	DC OUTPUT AMPS	LOAD REGULATION* ΔV INCREASE 100%-50% LOAD	LOAD REGULATION* ΔV INCREASE 100%-25% LOAD	LOAD REG. CURVE (Fig. 1)	RIPPLE (MAX) RMS VOLTS
PRM 6–15	6.3	0–15	0.5	0.8	1	0.4
PRM 12–10	12	0–10	0.6	1.0	2	0.4
PRM 18–6.7	18	0–6.7	0.8	1.3	3	0.3
PRM 24–5	24	0–5	1.0	1.7	3	0.3
PRM 28–4.3	28	0–4.3	1.2	2.0	4	0.3
PRM 36–3.3	36	0–3.3	1.5	2.4	5	0.3
PRM 48–2.5	48	0–2.5	2.0	3.4	6	0.3
PRM 60–2	60	0–2	2.3	3.8	7	0.3
PRM 120–1	120	0–1	4.6	7.6	9	0.3

*Measured at 115V AC Line.



CASED
Bottom view
3¹³⁄₃₂" x 5" x 13¹³⁄₁₆"

SIZE "C" - 300 SERIES DUAL OUTPUT



UNCASED
6¾" x 4¾" x 14⅜"

MODEL	DC OUTPUT VOLTS	DC OUTPUT AMPS	LOAD REGULATION* ΔV INCREASE 100%-50% LOAD	LOAD REGULATION* ΔV INCREASE 100%-25% LOAD	LOAD REG. CURVE (Fig. 1)	RIPPLE (MAX) RMS VOLTS
PRM 2X 4.5–20	4.5 4.5	0–20 0–20	0.5	0.7	1	0.3
PRM 2X 6–20	6.3 6.3	0–20 0–20	0.5	0.7	1	0.3
PRM 2X 12–12	12 12	0–12 0–12	0.5	0.7	1	0.3
PRM 2X 15–10	15 15	0–10 0–10	0.5	1.0	1	0.3
PRM 2X 18–8	18 18	0–8 0–8	0.6	1.6	1	0.3
PRM 2X 24–6	24 24	0–6 0–6	0.6	1.0	2	0.3
PRM 2X 28–5	28 28	0–5 0–5	0.7	1.2	2	0.3
PRM 2X 36–4	36 36	0–4 0–4	0.7	1.2	3	0.3
PRM 2X 48–3	48 48	0–3 0–3	0.8	1.4	3	0.3
PRM 2X 60–2.5	60 60	0–2.5 0–2.5	1.0	1.7	3	0.3

*Measured at 115V AC Line.



CASED
6¹⁵⁄₁₆" x 5" x 14⁷⁄₁₆"

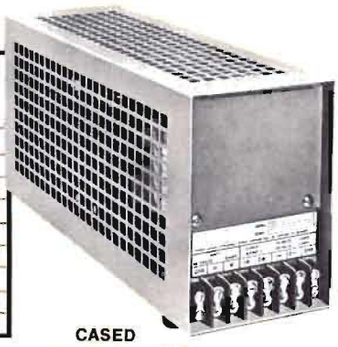
SIZE "C" - 180F SERIES EXTRA-FILTERED



UNCASED
6¾" x 4¾" x 14⅜"

MODEL	DC OUTPUT** VOLTS	DC OUTPUT** AMPS	LOAD REGULATION* ΔV INCREASE 100%-50% LOAD	LOAD REGULATION* ΔV INCREASE 100%-25% LOAD	LOAD REG. CURVE (Fig. 1)	RIPPLE (MAX) RMS VOLTS
PRM 6–25F	6.3	0–25	0.7	1.2	1	0.04
PRM 12–15F	12	0–15	0.9	1.4	2	0.02
PRM 18–10F	18	0–10	0.9	1.5	3	0.01
PRM 24–8F	24	0–8	1.2	2.0	3	0.005
PRM 28–7F	28	0–7	1.3	2.1	3	0.005
PRM 36–5F	36	0–5	1.5	2.4	4	0.005
PRM 48–4F	48	0–4	1.7	2.9	5	0.003
PRM 60–3F	60	0–3	2.3	3.6	6	0.003
PRM 120–1.5F	120	0–1.5	3.8	6.8	8	0.003

*Measured at 115V AC Line. **Less 2% filter drop (See ACCURACY)



CASED
6¹⁵⁄₁₆" x 5" x 14⁷⁄₁₆"



Model SM 14-7AM

KEPCO
SM
TRANSISTORIZED
POWER SUPPLIES

- *wide voltage range*
- *high current*
- *dual regulator*
- *minimum regulator dissipation*

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE AMPS	OUTPUT IMPEDANCE Ohms + Microhenries DC to 100 cps	100 cps to 1 kc	1 kc to 100 kc + μh	MAX. INPUT AMPS At 125 V AC	DIMENSIONS H"	W"	D"
SM 14–7AM	**0–14**	**0–7**	0.001	0.005	0.1 +0.4	3.5	3½	19	13⅞
SM 14–15AM	**0–14**	**0–15**	0.0005	0.005	0.02+0.4	5.5	5¼	19	13⅞
SM 14–30AM	**0–14**	**0–30**	0.0003	0.005	0.02+0.1	10.5	8¾	19	13⅞
SM 36–5AM	**0–36**	**0–5**	0.005	0.005	0.03+0.4	4.0	3½	19	13⅞
SM 36–10AM	**0–36**	**0–10**	0.003	0.005	0.03+0.4	6.5	5¼	19	13⅞
SM 36–15AM	**0–36**	**0–15**	0.002	0.005	0.03+0.4	10.5	8¾	19	13⅞
SM 75–2AM	**0–75**	**0–2**	0.02	0.005	0.04+0.4	4.0	3½	19	13⅞
SM 75–5AM	**0–75**	**0–5**	0.01	0.005	0.02+0.4	6.5	5¼	19	13⅞
SM 75–8AM	**0–75**	**0–8**	0.005	0.005	0.06+0.5	10.0	8¾	19	13⅞
SM 160–1AM	**0–160**	**0–1**	0.1	0.005	0.04+0.5	3.5	3½	19	13⅞
SM 160–2AM	**0–160**	**0–2**	0.05	0.005	0.04+0.4	5.5	5¼	19	13⅞
SM 160–4AM	**0–160**	**0–4**	0.02	0.005	0.06+1.0	10.5	8¾	19	13⅞
SM 325–0.5AM	**0-165-325**	**0–0.5**	0.4	0.005	0.1 +1.0	3.5	3½	19	13⅞
SM 325–1AM	**0–325**	**0–1**	0.2	0.005	0.1 +1.0	5.0	5¼	19	13⅞
SM 325–2AM	**0–325**	**0–2**	0.1	0.005	0.1 +1.0	11.0	8¾	19	13⅞

SPECIFICATION	VOLTAGE MODE
OUTPUT RANGE	0–100% E_O max.
REGULATION, LINE	<0.01%
REGULATION, LOAD	<0.05% or 1 mV*
STABILITY (8 HR).	<0.05% or 3 mV*
TEMP. COEFFICIENT	<0.05% per °C
RIPPLE, rms.	<1 mV

**whichever is greater*

INPUT: 105-125V AC, 60 ±1 cps single phase.

Overseas Models: Specify suffix "–50" for selectable 104 ±9V, AC; 115 ±10V AC; 208 ±18V AC; 230 ±20V AC, 50 cps ±1 cps. Derate *output voltage* range by 20% when ordering with "50" option.

TEMPERATURE, AMBIENT OPERATING: –20°C to +50°C.

TEMPERATURE, STORAGE: –40°C to +85°C.

COOLING: Forced air, lateral circulation. Built-in blower.

ISOLATION VOLTAGE: 400 volts to chassis.

CONTROL RESOLUTION: 0.1%, 10-turn voltage control.

VOLTAGE RECOVERY: (for step load current): 50 microseconds.

REMOTE ERROR SENSING: Compensates up to 0.5 volt drop per output lead.

OVERSHOOT: (Turn-on/off): None above 25% voltage setting; negligible below 25% when preloaded to 10% minimum.

METERS: Suffix "M" designates a pair of 2½", 2% meters. Delete suffix for unmetered unit.

SERIES OPERATION: To rated isolation.

TERMINALS: Binding posts front and rear for plus, minus and ground.

DIMENSIONS: See table for sizes.

FINISH: Per FED. STD. 595, Color 26440, light gray.

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

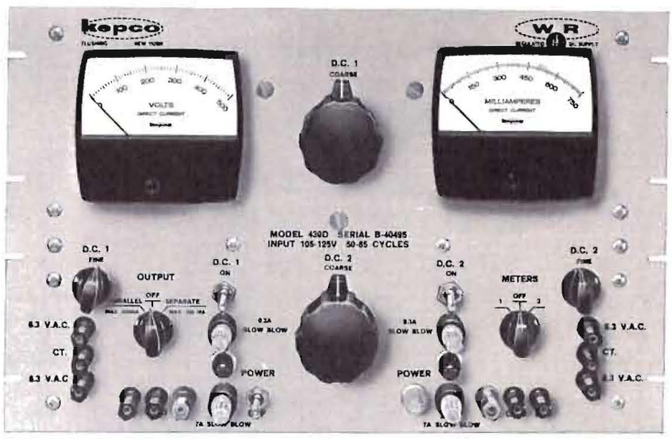
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VACUUM TUBE
POWER SUPPLIES

- *time tested vacuum tube design*
- *multi-output laboratory units*



Model 430D

MODEL	DC OUTPUT RANGE VOLTS	DC OUTPUT RANGE mA	REGULATION LOAD 0–MAX. %	REGULATION LOAD 0–MAX. ΔV	REGULATION LINE %	REGULATION LINE ΔV	RIPPLE RMS mV	OUTPUT IMPEDANCE Ohms + Microhenries DC to 100 CPS	OUTPUT IMPEDANCE 100 CPS to 1 KC	OUTPUT IMPEDANCE 1 KC to 100 KC + μH	AUXILLIARY OUTPUT 6.3V AC Unregulated	DIMENSIONS H	DIMENSIONS W	DIMENSIONS D	MAX. INPUT AMPS at 125 V AC
2400 B–#1	**Bias**														
	0–150	**0–5**	*	*	*	*	1	*	*	*		10½"	19"	17⅞"	5.0
#2	**0–400**	**0–150**	0.025	0.1	0.1	0.4	3	0.7	0.05	0.2+2	10 AMP				
#3	**0–400**	**0–150**	0.025	0.1	0.1	0.4	3	0.7	0.05	0.2+2	10 AMP				
Parallel #2 & #3	**0–400**	**0–300**	0.025	0.1	0.1	0.4	3	0.35	0.05	0.2+2					
Series #2 & #3	**0–800**	**0–150**	0.025	0.2	0.1	0.8	6	1.4	0.1	0.4+4					
400 B	**0–400**	**0–150**	0.025	0.1	0.1	0.4	3	0.7	0.05	0.2+2	10 AMP	7"	19"	11⅞"	3.0
	Bias														
	0–150	**0–5**	*	*	*	*	1	*	*	*					
430 D–#1	**0–450**	**0–300**	0.025	0.1	0.1	0.4	3	0.38	0.05	0.2+2	10 AMP	12¼"	19"	17⅞"	8.0
#2	**0–450**	**0–300**	0.025	0.1	0.1	0.4	3	0.38	0.05	0.2+2	10 AMP				
Parallel #1 & #2	**0–450**	**0–600**	0.025	0.1	0.1	0.4	3	0.19	0.05	0.2+2					
Series #1 & #2	**0–900**	**0–300**	0.025	0.2	0.1	0.8	6	0.76	0.1	0.4+4					
800 B–#1	**0–600**	**0–200**	0.02	0.1	0.1	0.4	3	0.6	0.05	0.2+2	10 AMP	12¼"	19"	17⅞"	7.5
#2	**0–600**	**0–200**	0.02	0.1	0.1	0.4	3	0.6	0.05	0.2+2	10 AMP				
Parallel #1 & #2	**0–600**	**0–400**	0.02	0.1	0.1	0.4	3	0.3	0.05	0.2+2					
Series #1 & #2	**0–1200**	**0–200**	0.02	0.2	0.1	0.8	6	1.2	0.1	0.4+4					
605	**0–600**	**0–500**	0.02	0.1	0.1	0.4	3	0.24	0.05	0.2+2	20 AMP	10½"	19"	17⅞"	8.0
	Bias														
	0–150	**0–5**	*	*	*	*	1	*	*	*					
615B	**0–600**	**0–300**	0.02	0.1	0.1	0.4	3	0.4	0.05	0.2+2	10 AMP	10½"	19"	13⅞"	6.0
	Bias														
	0–150	**0–5**	*	*	*	*	1	*	*	*					
103–#1	**0–300**	**0–75**	Common B– Isolated from #1 and #2 Unregulated				30	—	—	—	5 AMP	8"	16"	8"	1.5
#2	**0–300**	**0–75**					30	—	—	—					
#3	**–50 to +50**	**0–5**					10	—	—	—		Rack Adapter RA-1 Available, See Accessory Page			
Parallel #1 & #2	**0–300**	**0–150**					30	—	—	—					
1250 B ◇	**0–1000**	**0–500**	0.01	0.1	0.05	0.4	3	0.2	0.1	1.0+2		28"	22"	15½"	12.5
1520 B ◇	**0–1500**	**0–200**	0.01	0.1	0.05	0.4	3	0.75	0.3	1.0+5		23"	22"	15½"	7.0
HB 2050 ◇	**0–2000**	**0–500**	0.005	0.1	0.02	0.4	3	0.2	0.5	2.0+5		33½"	22"	18"	24.0
HB 2500	**0–2500**	**0–50**	0.005	0.1	0.02	0.4	5	2.5	0.5	2.0+5		8¾"	19"	14"	5.0

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

INPUT:
105-125V AC, 50-65 cps single phase, 400 cps input available on special order.

TEMPERATURE, AMBIENT OPERATING:
–20°C to +55°C

TEMPERATURE, STORAGE:
–40°C to 85°C

COOLING: Convection.

ISOLATION VOLTAGE:
400 volts to chassis.

CONTROL RESOLUTION:
0.5% single turn controls on all models except 2400B, 430D, 800B and HB 2500, which employ a coarse and fine adjustment. The "fine" control covers a 1% voltage range with 0.005% resolution.

VOLTAGE RECOVERY, (for step load current):
< 50 microseconds.

TERMINALS:
Output and ground terminals are on the front panel, except Models 2400B, HB 2050 and HB 2500, which have the terminals at the rear.

DIMENSIONS:
The dimensions for each model are tabulated, models with the ✧ symbol are supplied in a rack cabinet. They may be removed for mounting in any standard 19" equipment rack.
The equipment rack dimensions are:

	H	W	D
1250B	26¼"	19"	13⅞"
1520B	21"	19"	13⅞"
HB 2050	31½"	19"	17⅞"
103	(Use with Rack Adapter RA-1)		

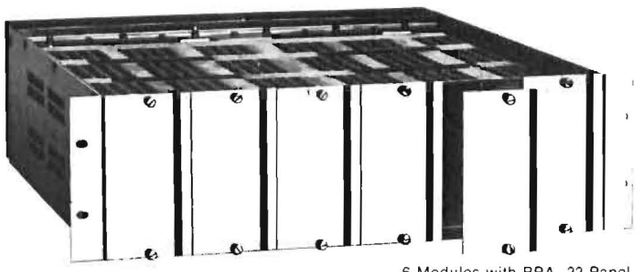
FINISH:
Cabinet: Gray hammertone.
Panel: Per FED. STD. 595, Color 26440, light gray.

Data subject to change without notice
PATENT NOTICE: Applicable Patent Nos. will be supplied on request.

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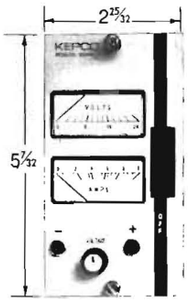


6 Modules with BPA–22 Panel Adapters in Rack Cabinet RA 22-6

HARDWARE, ADAPTERS and ACCESSORY ITEMS for OPS, OPS-TA, PAX, PBX and PBX-MAT MODULES

MODEL	DESCRIPTION	SIZE
RA 22–6	Six-slot rack housing w/o plug boards*	5 7/32" H x 19" W x 16 3/8"D
BPA–22	Blank panel assembly w/slide plate	5 7/32" H x 2 25/32"W x 14 5/8" D
RFP 22–1	Single filler panel for RA 22–6	5 7/32" H x 2 25/32"W ——
RFP 22–2	Double filler panel for RA 22–6	5 7/32" H x 5 5/16"W ——
RFP 22–3	Triple filler panel for RA 22–6	5 7/32" H x 8 3/8" W ——
CA–1	Chassis mounting case (single)	2 1/16"H x 4 1/8" W x 13 3/16"D
CA–3	Single-slot housing w/plug board	5 7/32" H x 2 25/32"W x 16" D
CA–4	Double-slot housing w/plug board	5 7/32" H x 5 9/16"W x 16" D
CA–5	Triple-slot housing w/plug board	5 7/32" H x 8 3/8" W x 16" D
RA 12–1	1 unit Rack Adapter (cased)	3 15/32"H x 19" W ——
RA 13–4	4 unit Rack Adapter (cased)	3 15/32"H x 19" W ——
RA 11–6	6 unit Rack Adapter (cased)	5 7/32" H x 19" W ——
PC–1	Printed circuit board connector	—— —— ——
PC–2	Plug-in adapter*	5 7/32" H x 2 21/32"W ——

*For plug-in convenience in the RA 22–6, use (1) PC–2 per slot.

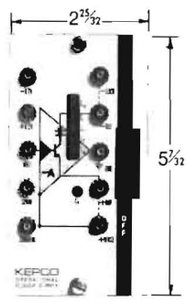


METER, ADJUSTMENT and TERMINAL ASSEMBLIES for PBX MODULES

MODEL	FOR USE WITH
MAT–7	Model PBX 7–2
MAT–15	Model PBX 15–1.5
MAT–21	Model PBX 21–1
MAT–40	Model PBX 40–0.5
MAT–72	Model PBX 72–0.2
MAT–100	Model PBX 100–0.2

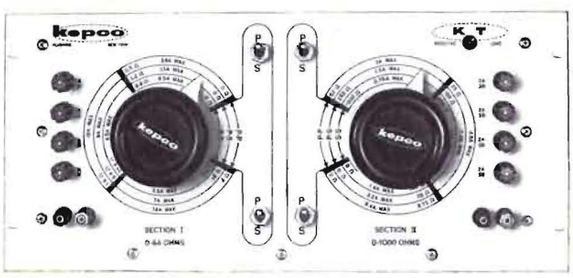
TERMINAL/ADJUSTMENT ASSEMBLIES for OPS MODULES

MODEL	FOR USE WITH
TA–7	Model OPS 7–2
TA–15	Model OPS 15–1.5
TA–21	Model OPS 21–1
TA–40	Model OPS 40–0.5
TA–72	Model OPS 72–0.3
TA–100	Model OPS 100–0.2



Panels finished per FED. STD. 595 Color 26440 (light gray).

VARIABLE RESISTIVE LOAD



The Model KT 6212 is a multiganged, eight-section group of dual-wound power rheostats used in the testing of regulated power supplies.

Model KT 6212 consists of two independent gangs of four rheostats apiece, 0-64 ohms and 0-1000 ohms. The rheostats can be switched for parallel, series parallel and series operation. Each rheostat has heavy and light windings so that the maximum load current changes at approximately each third rotation point around the dial.

CONTROLS:
Switches select series and parallel combinations of the four ganged rheostats with the corresponding resistance and current rating designated by concentric bands.

Each band defines the resistance range for its particular connection with zero ohms (maximum current) in the clockwise position. The bands are divided into three sections that correspond to the position of the heavy and light windings, respectively. The maximum current in each section is shown on the corresponding portion of the band.

FUSING:
Each rheostat in the 0-64 ohm gang is fused at 7 amperes. Each rheostat of the 0-1000 ohm gang is fused for 2 amperes.

TERMINALS:
A pair of 5-way binding posts is provided at each gang for connection to the power source under test. These connections are duplicated at the rear.

EXTERNAL POWER REQUIREMENTS:
None. The Model KT 6212 is a passive device.

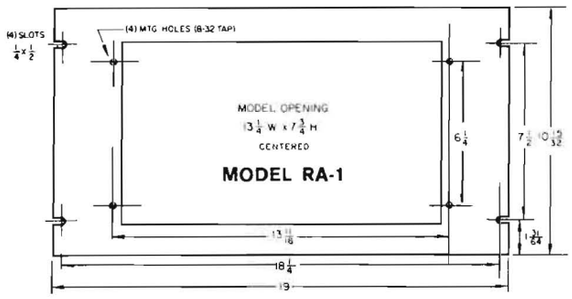
DIMENSIONS:
8¾"H x 19"W x 13⅝"D. The Model KT 6212 resistive load is designed for mounting in standard 19" equipment racks.

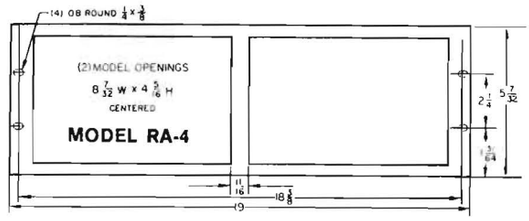
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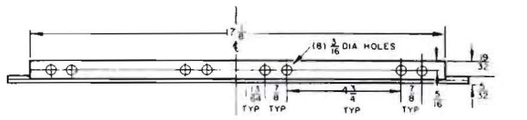
RACK ADAPTERS

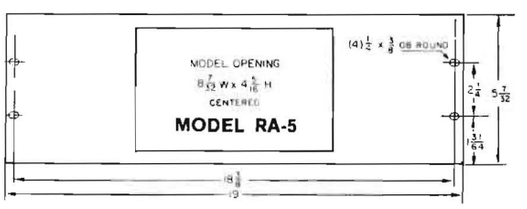
Rack Adapters are manufactured by Kepco to adapt bench style, modular and half-rack Power Supplies to the standard 19" wide equipment rack or cabinet.

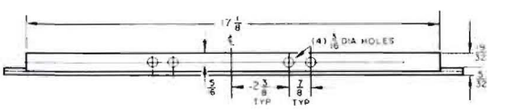
Panels and Rack Adapters are finished per FED. STD. 595. Color 26440, (light gray).











RACK ADAPTERS for ABC, CK, FG–100, KP–1, MP–1, MP–10, OPS-1A and VIX 1–C.

MODEL	FOR USE WITH	DIMENSIONS H	W
RA 1 *(Single)*	Model 103 only	10½"	19"
RA 4 *(Dual)*	Above Listed Models	5⅞2"	19"
RA 5 *Single)*	Above Listed Models	5⅞2"	19"
FP1	Filler Panel for RA 4	4¼"	8⅝2"

HARDWARE, ADAPTERS and ACCESSORY ITEMS

PANEL MOUNTING HOLES ARE PRE-DRILLED IN STANDARD E.I.A. PATTERN

PAR, PRM Size "A" – 180 Series and PWR GROUPS

MODEL	DESCRIPTION	DIMENSIONS H	W	D
CA–200	Case	6⁵⁄₁₆"	5"	10⅞"
RA 8–2	2 Unit Rack Adapter	5⅞2"	19"	—
RA 9–3	3 Unit Rack Adapter	6³½2"	19"	—
RA 10–1	1 PRM Unit Rack Adapter	5⅞2"	19"	—
RA 23–1	1 PWR Unit Rack Adapter	5⅞2"	19"	—
RA 25–1	1 PAR Unit Rack Adapter	5⅞2"	19"	—

PRM Size "B" – 120 Series Group

RA 14–3	3 Unit Rack Adapter	3¹⁵⁄32"	19"	—
RA 15–1	1 Unit Rack Adapter	3¹⁵⁄32"	19"	—
RA 16–4	4 Unit Rack Adapter	5⅞2"	19"	—
RA 17–5	5 Unit Rack Adapter	5⅞2"	19"	—

PRM Size "C" – Dual Output and Extra-Filtered GROUPS

CA–300	Case	6⁵⁄₁₆"	5"	14⅞"
RA 8–2	2 Unit Rack Adapter	5⅞2"	19"	—
RA 9–3	3 Unit Rack Adapter	6³½2"	19"	—
RA 18–1	1 Unit Rack Adapter	5⅞2"	19"	—

PLUG-IN CABINETS for PRM Size "A" & "C"

RA 20–3	3 Unit Housing	8²³⁄32"	19"	18"
RAP 20–1	1 Unit Panel Adapter	8²³⁄32"	5½"	—
RFP 20–1	Rack Filler Panel	8²³⁄32"	5½"	—

PLUG-IN CABINETS for PAR and PWR GROUPS

RA 21–3	3 Unit Housing	8²⁵⁄32"	19"	13"
RAP 21–1	1 Unit Panel Adapter	8²⁵⁄32"	5½"	—
RFP 21–1	Rack Filler Panel	8²⁵⁄32"	5½"	—

KG GROUP

MODEL	DESCRIPTION			
CA–2	Single Unit Housing	5⅛2"	2³⁄16"	14"
RA 19–8	Multi Unit Housing (8)	5¼"	19"	14"
RFP 19–1	Single filler panel	5⅞2"	2³⁄16"	—
RFP 19	Double filler panel	5⅞2"	4³⁄16"	—
RFP 19	Triple filler panel	5⅞2"	6⁵⁄16"	—

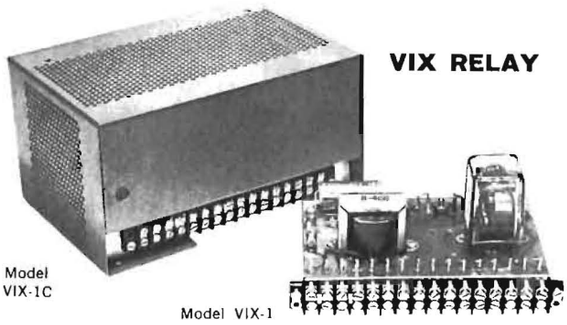
CDT and OPS–2000

RA 24*	Double 5¼" half-rack	5⅞2"	19"	17⅞"
RFP 24–2	Filler panel for RA 24	5⅞2"	8¹³⁄32"	—

*Pre-drilled for Jonathan Slides 110 QD 20–1, 22–1, 24–1.

PAT GROUP

RA 26–1	1 Unit Rack Adapter	3¹⁵⁄32"	19"	—
RA 27–2	2 Unit Rack Adapter	3¹⁵⁄32"	19"	—
RA 28–4	4 Unit Rack Adapter	6³¹⁄32"	19"	—



VIX RELAY

Model VIX-1C translates the VIX REMOTE SIGNAL available on all CK and KS VIX-equipped power supplies into a heavy duty relay closure for external control or signal applications.

SPECIFICATIONS

INPUT: ±8V DC at 1 ma (from VIX signal).

OUTPUT: Three pole, double throw relay contacts; each rated to carry 10 amperes at 115V AC or 5 amperes at 230V AC.

POWER REQUIREMENTS: 105-125V or 210-250V AC

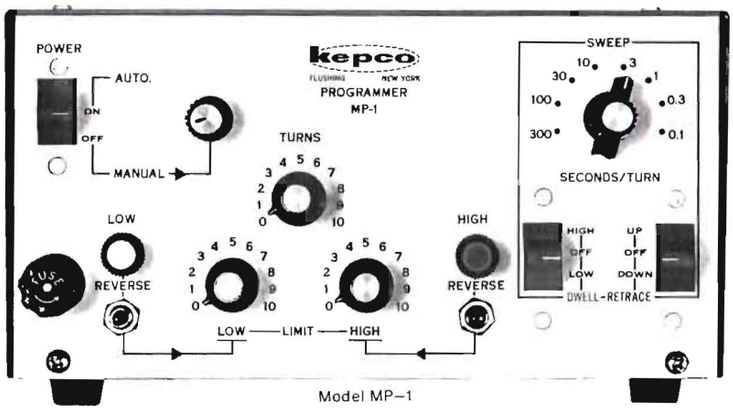
SIZE: 4¼" H x 8$^{5}/_{32}$" W x 5" D (5⅝" D overall) Standard half-rack configuration).

MOUNTING: In the half-rack enclosure VIX-1C can be mounted in either RA-4 or RA-5 rack adapters.
The enclosure is removable so that the circuit board, which is complete by itself, can be mounted within other equipment or chassis. To designate model without enclosure, delete the suffix "C", e.g., Model VIX-1, for unenclosed circuit board for "built-in" mounting.

KEPCO

MOTORIZED PROGRAMMERS

MECHANICAL FUNCTION GENERATOR



Model MP-1

Models MP-1 and MP-10 are mechanical drives for a 10-turn servo-mount potentiometer installed within. A synchronous motor drives the shaft through an 8-speed gear-box with adjustable limits.

MODELS	SECONDS PER REVOLUTION (MAXIMUM: 10 REVOLUTIONS, 3600°)							
MP–1	0.1	0.3	1.0	3.0	10.0	30.0	100.0	300.0
MP–10	1.0	3.0	10.0	30.0	100.0	300.0	1000.0	3000.0

TIMING ACCURACY: ±5% referenced to 60 cps line frequency.

LIMITS, (Mechanically Adjustable):

Low Limit: Range from 0-9⅔ turns.
High Limit: Range from ⅓ to 10-turns.
Minimum Sweep Range: ⅓ turn (120°)

OVERIDE: Manual override buttons reverse the sweep at any desired point–or manually stop the programmer.

DIRECTION SIGNALS: Pilot lights signal the direction of sweep up and down. With dwell and retrace off, sweep cycles symmetrically between limits.

DWELL: Stops the sweep at either the high or low limit, (selectable).

RETRACE: Selector causes the sweep to retrace up or down at maximum speed–no matter what the speed selected.

AVAILABLE POTENTIOMETERS: Any ⅛" shaft, ⅞" servo-mount potentiometer. *Standard values:* 10, 25, 50, 100 and 500 ohms; 1, 2, 5, 10, 30, 50, 75, 90, 100 and 125 kilohms. Other resistance values on special order.

TERMINALS: Rear mounted barrier strip contains speed changing connections: high and low limit contacts, dwell and retrace, and the output of the linear potentiometer.

DIMENSIONS: 4¼"H x 8$^{5}/_{32}$"W x 9⅝"D.

FINISH: *Panel:* Per FED. STD 595. Color 26440, (light gray).
Case: Gray hammertone.

MOUNTING: Bench style, single and dual rack mounting adapters available.

All terms used in the specifications are defined in the Kepco Glossary on Page 33.

Data subject to change without notice
PATENT NOTICE: Applicable Patent Nos. will be supplied on request.

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PROGRAMMER, FUNCTION GENERATOR
MODEL FG-100



Model FG-100 is a precision, slow speed, triangular waveform generator capable of generating any repetitive ramp function. Separately adjustable, high and low limits, are provided which periodically reverse the direction of the integration. The rising rate and falling rate are separately adjustable or can be controlled symmetrically with a single control.

SPECIFICATIONS

OUTPUTS:

#1 — 0-20V DC, 0-20 ma.

#2 — 0-10 ma to program 100 ohm/volt power supply.

#3 — 0-1 ma to program 1000 ohm/volt power supply.

All outputs available simultaneously.

INPUT: 105-125V or 210-250V AC, 50-440 cps.

TIMING: 4 ranges: 0.1V/sec., 1.0V/sec., 10V/sec., 100V/sec. Rising and falling slopes continuously adjustable between ranges either separately or symmetrically. For outputs #2 and #3, divide the above timing by 2000 and 20,000 respectively to obtain milliamperes per second.

LIMITS: Separately adjustable high limit and low limit permits operation between any two pre-set voltages or currents.

REVERSING SWITCHES: Programming direction is automatically reversed at the high and low limits. In addition, a pair of push buttons are provided which permit the direction to be reversed at any point in the operating span. A pair of directional lamps are provided to show the direction of the ramp.

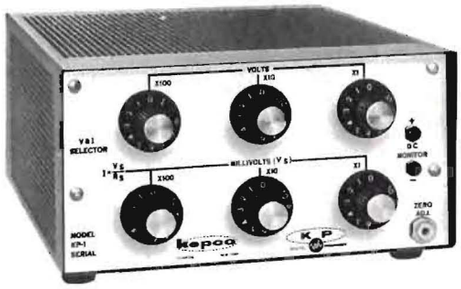
METER: 2½" edgewise meter monitors output in volts (0-20V DC) and in percent of maximum output, 0-100%.

PROGRAMMING: Model FG-100 may be used by itself to generate a wide variety of very low speed triangular or sawtooth functions, or it can be used directly with any programmable DC power supply. When connected to a programmable power supply, the Model FG-100 Function Generator programs the power supply throughout all or part of its rated voltage or current range as set by the power supply's controls and the function generator's limit settings. NOTE: function speed is converted to programming speed by multiplying the driving current rate (ma/sec.) by the resistance setting of the voltage control of the power supply being programmed. This gives the programming speed of the power supply's output in volts per second.

REMOTE CONTROLS: Timing and limit setting controls are brought to a multi-terminal barrier strip at the rear of the unit for remote operation. A sync output is also provided as is provision for remote directional signals.

SIZE: 4¼" H x 8$\frac{5}{32}$" W x 13" D (13⅜" D overall); standard half-rack configuration, fits Rack Adapters RA-4 and RA-5.

PROGRAMMING PANELS



MODEL KP-1 for use with any Kepco programmable power supply using a 1 mA control current.

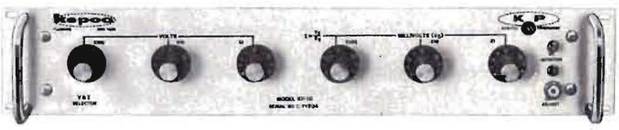
SPECIFICATIONS: MODEL KP-1

DECADES: 6-digit voltage programming. 3-digit current programming.

RANGE: 0-1,011.110 ohms in 1 ohm steps (0 to 1,011.110V in 1 millivolt steps at 1000Ω/V).

ACCURACY: Decades contain 0.1% resistor except units decade (millivolts) which contain 1% resistors.

SIZE: Half-rack, 4¼"H x 8$\frac{5}{32}$"W x 9⅝"D. Fits Rack Adapters RA-4 or RA-5.



MODEL KP-10 for use with any Kepco programmable power supply using a 10 mA control current.

SPECIFICATIONS: MODEL KP-10

DECADES: 6-digit voltage programming. 3-digit current programming.

RANGE: 0-101,111.0 ohms in 0.1 ohm steps (0-1,011.110V in 1 millivolt steps at 100Ω/V.)

ACCURACY: All decades contain 0.1% resistors.

SIZE: 3½"H x 19"W x 11"D. Standard rack mount configurations.

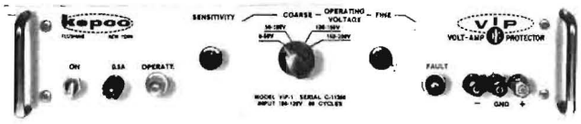
Both decade programmers contain provision for current programming using the first three digits. This assumes a 1 volt sensing drop (internal or external). If the recommended 10 volt sample is employed for HB and ABC high voltage hybrids, then a fourth digit can be used for higher resolution.

When substituted in place of a power supply's normal voltage control and calibrated, the KP-1/KP-10 digital decade programmer converts that supply to a highly accurate voltage or current source.

Both programmers contain zero trimming controls which, in conjunction with the power supplies own bridge current adjustment, allow precise calibration of the output at minimum and maximum output. The programming function of the Kepco bridge is inherently linear to an accuracy determined by the load/line regulation of the power supply. This means that the circuit accuracy is, for all intents and purposes, limited solely by the resistors used in the programmer.

KEPCO

OVER-VOLTAGE / OVER-CURRENT PROTECTORS



Model VIP—1 OVER-VOLTAGE/OVER-CURRENT

Model VIP—3 OVER and UNDER-VOLTAGE OVER and UNDER-CURRENT

Model VIP—4 200 AMPERE OVER-VOLTAGE CROWBAR. Range: 0-50 volts

The VIP consists of a sensing circuit capable of detecting a voltage 1% or 0.1 volts different than any preset voltage limit in the range 5—200 volts. Should such an over or under-voltage occur, a fast-acting silicon controlled rectifier (SCR) "crowbar" short circuits the power supply's output within 50 microseconds. Simultaneously a power interlock relay is tripped which removes the primary AC power within approximately 50 milliseconds. The SCR discharges the power supply's output filter capacitor and the voltage is reduced to zero.

Operation in the internal reference mode allows the operator to pre-set any voltage as a limit above or below which crowbar/turn-off action is precipitated. In its tracking mode, the VIP is interconnected with the voltage control circuit of the power supply with which it is used and will sense a voltage differential between the output of the supply and the programmed voltage.

Terminals are provided for the addition of a sensing resistor to convert VIP into an over-current or under-current protector depending on model. The current sensing resistor is chosen to drop 1 volt at the operating current. The sensitivity control then adjusts the firing threshold from 0 to the operating current, maximum 30 amperes.

SPECIFICATIONS:

VOLTAGE

SENSITIVITY: Minimum threshold 1% of operating voltage or 0.1 volts whichever is greater (adjustable).
RANGE: 0–50V*, 50–100V, 100–150V, 150–200V.
*Minimum voltage required for proper operation is 5V.

CURRENT

SENSITIVITY: 5% of operating current producing a 1 volt drop across external sensing resistor.

RANGE: 0-30 amperes. Model VIP 4 has a 0-200 ampere crowbar range.

POWER INTERLOCK RELAY

CONTACT RATING: 10 amperes at 115V AC.

Operation of the VIP is in two stages. The output crowbar is immediately followed by an AC power interruption to the crowbarred power supply. High power supplies (such as might require a VIP 4) may require either an auxiliary contactor to turn them off, or, in the case of the large KS and KO models, a connection may be made to the trip coil of the power supply's circuit breaker to accomplish the turn-off action.

DIMENSIONS

3½" high x 19" wide x 8" deep.
Standard EIA rack dimensions.

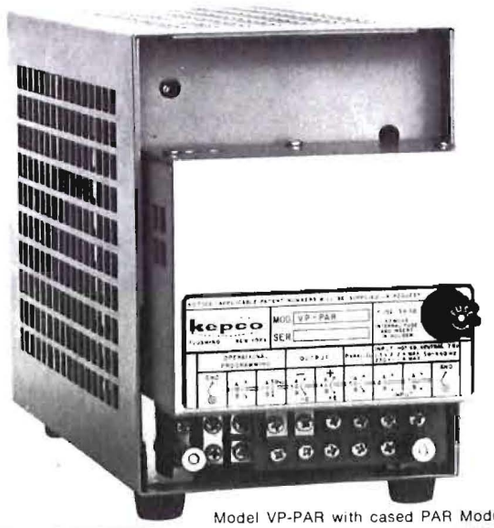
FINISH: Per FED. STD. 595. Color 26440 (light gray).

NOTE: When a VIP is to be used in its "Tracking Mode" be sure to specify (when ordering) whether it is to be used with a *plus* common or *minus* common power supply.

Data subject to change without notice
PATENT NOTICE: Applicable Patent Nos. will be supplied on request.

OVER-VOLTAGE PROTECTORS

Independently powered overvoltage crowbar prevents the output voltage from exceeding a preset voltage under any failure condition. The crowbar shorts the output through a Silicon Controlled Rectifier (SCR).



Model VP-PAR with cased PAR Module

MODELS	USE WITH
VP–PAR	ALL KEPCO PAR MODELS, 3–80V DC
VP–PWR	ALL KEPCO PWR MODELS, 3–80 V DC
VP–PX–1	KEPCO PAX & PBX MODELS, 3–80V DC
VP–PX–2	KEPCO PAX & PBX MODELS 3–160V DC

SPECIFICATIONS:

OPERATING LEVEL:
The trigger point may be set to within 5% or 0.25V (whichever is greater) of power supply setting.

TEMPERATURE COEFFICIENT:
0.1% or 0.1V (whichever is greater) per °C.

REMOTE ERROR SENSING:
Compensates up to 1 volt per output lead.

TRIGGERING TIME, (adjustable delay):

RANGE OF ADJUSTMENT	AMOUNT OF OVERVOLTAGE
5 to 10 microseconds	20% or 1 volt
8 to 16 microseconds	10% or 0.5 volt
12 to 24 microseconds	5% or 0.25 volt

AUTOTRANSFORMERS



Compact step-down Transformers provide 115V AC output from 220/230/240V AC (tap selected) 48—440 cps.

MODEL	POWER	L	SIZE* W	D
AT–100	100 VA	5½"	2⅞"	2¾"
AT–250	250 VA	6"	3½"	3½"
AT–500	500 VA	7½"	3½"	4½"
AT–1000	1000 VA	8"	5¼"	5¼"
AT–1500	1500 VA	9¼"	5¼"	6½"

*Overall case dimensions (not including handle and feet)

GLOSSARY OF POWER SUPPLY TERMS

accuracy—Accuracy, used as a specification for the output voltage of fixed voltage power supplies, refers to the absolute voltage tolerance with respect to the stated nominal output.

bipolar—Having two poles, polarities or directions. Applied to amplifiers or power supplies, it means that the output may vary in either polarity from zero; as a symmetrical program, it need not contain a d-c component. (See Unipolar)

bridge current—A current derived from the quotient of reference voltage by reference resistor (input resistor) circulating around the loop formed by the output elements and voltage control resistance (feedback resistor). The passage of this current through the voltage control resistance develops the voltage that programs the output of a power supply; 1mA current for 1000 ohms per volt, 10 mA for 100 ohms per volt, etc. (See Figure 1)

calibration, programming—Calibration with reference to power supply programming describes the adjustment of the control bridge current to calibrate the programming ratio in ohms per volt. Many programmable supplies incorporate a "calibrate" control as part of the reference resistor which performs this adjustment. (See Figure 1)

closed-loop gain (operational gain) — The gain, measured with feedback, is the ratio of the voltage appearing across the output terminal pair to the causative voltage required at the input resistor. The closed-loop (operational) gain is denoted by the symbol (G) in diagrams and equations. If the open-loop gain (A) is sufficiently large, the closed-loop gain can be satisfactorily approximated by the ratio of the feedback resistor R_f to the input resistor R_1. (See Open-loop, Loop Gain)

command reference—In a servo or control system, the voltage or current to which the feedback signal is compared. As an independent variable, the command reference exercises complete control over the system output. (See Operational Programming).

common point—The terminal which is common between the programming input (inverting connection) and the output of an operationally controlled power supply. The common point may be either the plus (+) error-sensing terminal or the minus (—) error-sensing terminal, depending on the design. (See Figure 1).

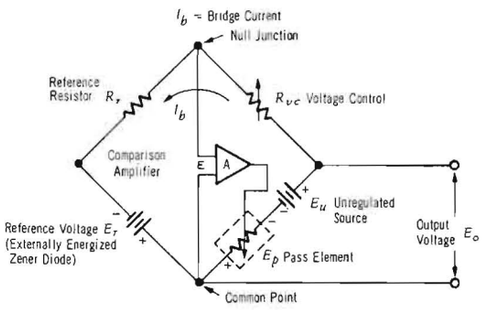


Figure 1—Kepco comparison bridge connected as a voltage regulator.

comparison amplifier—A high gain, non-inverting d-c amplifier which, in a bridge-regulated power supply, has as its input the voltage between the null junction and the common terminal. The output of the comparison amplifier drives the series pass elements. (See Figure 1).

comparison bridge—A type of voltage comparison circuit whose configuration and principle of operation resemble a four-arm electrical bridge (Figure 1). The elements are so arranged that, assuming a balance exists in the circuit, a virtual zero error signal is derived. Any tendency for the output voltage to change in relation to the reference voltage creates a corresponding error signal, which, by means of negative feedback, is used to correct the output in the direction toward restoring bridge balance. (See Error Signal).

complementary tracking—A system of interconnection of two regulated supplies in which one (the master) is operated to control the other (the slave). The slave supply voltage is made equal (or proportional) to the master supply voltage and of opposite polarity with respect to a common point. (See Figure 2).

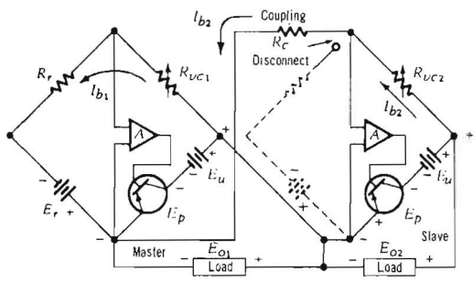


Figure 2—Master/slave series connection for the all-transistor power supplies (using PNP pass transistors).

compliance extension—A form of master/slave interconnection of two or more current regulated power supplies to increase their compliance voltage range through series connection.

compliance voltage—The output voltage of a d-c power supply operating in constant current mode. The compliance range is the range of voltages needed to sustain a given value of constant current throughout a range of load resistances.

constant current power supply (current regulator)—A power supply capable of maintaining a preset current through a variable load resistance. This is achieved by automatically varing the load voltage in order to maintain the ratio E_{load}/R_{load} constant.

constant voltage power supply (voltage regulator)—A power supply that is capable of maintaining a preset voltage across a variable load resistance. This is achieved by automatically varying the output current in order to maintain the product of load current times load resistance constant.

control ratio—The required change in control resistance to produce a one volt change in the output voltage of a power supply. The control ratio is expressed in ohms per volt and is the reciprocal of the bridge current. (See Figure 1).

control range—The range of voltage or current over which a controlled parameter may be adjusted.

cooling—The process of removing heat. Power supplies are cooled by transferring their heat of dissipation to the air. Methods include convection and forced-air circulation. Heat removal by direct radiation and by conduction also occurs.

crossover, automatic—The form of an output locus on the E/I plane consisting of independently adjustable, perpendicular voltage and current lines intersecting at the "crossover point." Power supplies having an automatic crossover characteristic operate equally well as voltage or current sources, the mode of operation being a function of the intersection between the load, line and the E/I locus. (See Figure 3)

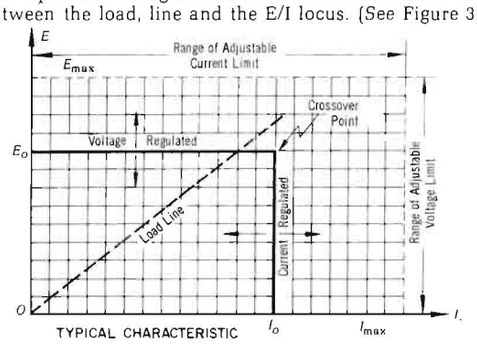


Figure 3–Automatic voltage/current crossover.

crowbar—An electrical short circuit intended to forcibly clamp the output voltage of a power supply. Crowbars are often used in connection with various overvoltage protectors. Silicon-controlled rectifiers are often used for this purpose.

current compensation—A means of compensating the inevitable shunt conductance in circuits connected across the terminals of a current regulator, similar to the error sensing provisions of a voltage regulator.

current cutoff — An overload protective mechanism designed into certain regulated power supplies to automatically *reduce* the load current as the load resistance is *reduced*. This "negative resistance" characteristic reduces overload dissipation to negligible proportions and protects sensitive loads. (See Figure 4).

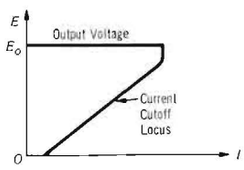


Figure 4–Output characteristic of a power supply equipped with a current cutoff overload protector

current limiting—An overload protective mechanism which resembles automatic crossover except that the current locus is not so tightly regulated and is intended for protection rather than constant current operation. (See Figure 5).

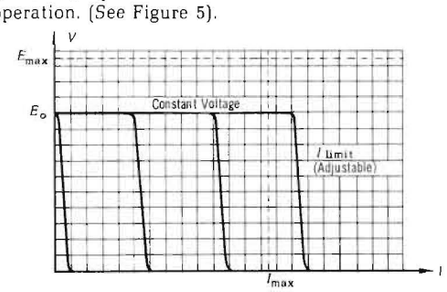


Figure 5–Plot of typical current limiting curves.

current sensing resistor—A resistor placed in series with the load to develop a voltage proportional to load current. A current regulated d-c power supply regulates the current in the load by regulating the voltage across the sensing resistor.

drift—(See Stablity)

error signal — The error signal is the difference between the output voltage and a fixed reference voltage compared in ratio by the resistors at the null junction of a comparison bridge.
$\varepsilon = E_o - E_r (R_{vc}/R_r)$ (See Figure 1)
The error signal is amplified to drive the series pass elements and correct the output.

feedback—The process of returning part of the output from a system to its input. If out of phase, this has the effect of cancelling part of the output, reducing the input/output gain. The use of feedback is fundamental to all control systems, including power supplies. The feedback attenuates the errors in proportion to the amount of feedback and provides the regulation.

feedback capacitor—A capacitor placed in the feedback path to alter the a-c feedback characteristic. The capacitor may be used for either lead or lag phase compensation.

feedback resistor — In an inverting amplifier, the resistor that couples output to input is called the feedback resistor, R_f. In a power supply employing the operational design concept, the feedback resistor corresponds to the voltage control. (See Figure 6).

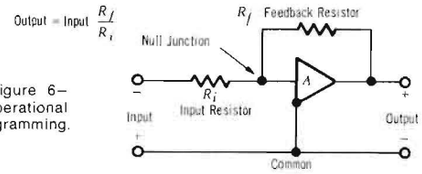


Figure 6–Operational programming.

filters—Filters are RC or LC networks arranged as low pass devices to attenuate the varying components that remain when an a-c voltage is rectified. In power supplies without subsequent active series regulators; the filters determine the amount of "ripple" that will remain in the d-c output. In supplies with active feedback series regulators, the *regulator* mainly controls the ripple with output filtering serving chiefly for phase-gain control as a *lag* element and as an energy storage to minimize output voltage transients.

FLUX-O-TRAN®—A registered trademark of Kepco, Inc., applied to ferro-resonant voltage regulating transformers of a special design, which are used in many proprietary designs. The Flux-O-Tran, with its resonating capacitor provides a squared-wave output (for high rectifier and filter efficiency) whose magnitude is largely independent of the primary voltage amplitude. (See Figure 7).

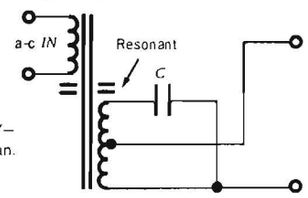


Figure 7–Kepco Flux-O-Tran.

frequency response—The measure of an amplifier or a power supply's ability to respond to a sinusoidal program. The frequency response measures the maximum frequency for undistorted full output voltage excursion.

$$f_{max} = \frac{dv}{dt}\left[\frac{1}{\pi E_{pp}}\right]$$

heat rise—The temperature increase due to self-heating. In power supplies, as in all dissipative devices, good design must allow for the anticipated heat rise internally in *addition* to the external environmental temperature.

heat sink—A thermal sink used to enhance the transfer of heat from its dissipative sources (pass transistors, rectifiers, etc.) to the external environment. A heat sink is ordinarily a relatively large metallic (usually copper or aluminum) structure to which the heat sources are fastened, and which is, in turn, ar-

ranged to transfer the heat to an exchange medium (water, air, etc.)

high speed regulator (fast slewing)—A power supply regulator which, by the elimination of capacitors from its output filter, is capable of rapid programming of output voltage and/or quick response as a current source.

hybrid—A combination of disparate elements to form a common circut. In Kepco power supplies, hybrid refers to the combination of vacuum tubes and transistors in a regulating circuit used for the control of high voltage.

impedance transformer–An operationally controlled power supply functions as a voltage follower having high input impedance and low output impedance in a noninverting amplifier configuration, with unity voltage gain.

inverting amplifier—An amplifier whose output polarity is reversed as compared to its input. (See Phase Shift.) Such an amplifier obtains its negative feedback by a connection from output to input, and, with high gain, is widely used as an operational amplifier. An operational d-c power supply can also be described as a high gain inverting amplifier. (See Figure 6).

isolation voltage—A rating for a power supply which specifies the amount of *external* voltage that can be connected between any output terminal and ground (the chassis). This rating is important when power supplies are connected in series.

lag networks — Resistive-reactive components, arranged to control phase-gain rolloff versus frequency. Used to assure the dynamic stability of a power supply's comparison amplifier. The main effect of a lag network is a reduction of gain at relatively low frequencies.

lead networks — Resistive-reactive components, arranged to control phase-gain rolloff versus frequency. Used to assure the dynamic stability of a power supply's comparison amplifier. The main effect of a lead network is to introduce a phase lead at the higher frequencies, near the unity gain frequency.

linearity, programming,—The linearity of a programming function refers to the correspondence between incremental changes in the input signal (resistance, voltage or current) and the consequent incremental changes in power supply output. Direct programming functions are inherently linear for the Kepco bridge regulator, and are accurate to within a percentage equal to the supply's regulating ability.

loop gain—A measure of the feedback in a closed-loop system, being equal to the ratio of the open-loop to the closed-loop gains, (in db, A-G). The magnitude of the loop gain determines the error attenuation and, therefore, the performance of an amplifier used as a voltage regulator. (See Open-loop *and* Closed-loop Gain).

loop (leakage) current—(See Offset Current.)

master-slave operation—A system of interconnection of two regulated power supplies in which one (the master) operates to control the other (the slave). Specialized forms of the master-slave configuration are used for: *Complementary Tracking* (plus and minus tracking around a common point): *Parallel Operation*, to obtain increased current output for voltage regulation; *Compliance Extension*, to obtain increased voltage output for current regulation. (See Figure 2).

modular—The term "modular" is used to describe a type of power supply designed to be built into other equipment, either chassis or rack mount. It is usually distinguished from laboratory bench equipment by a large choice of mounting configurations and by a lack of meters and controls.

MTBF (mean time between (or before) failure)—A measure of reliability giving either the time before first failure or, for repairable equipment, the average time between repairs. MTBF may be approximated or predicted by summing the reciprocal failure rates of individual components in an assembly.

null junction—The input terminal of the voltage amplifier to which the input or reference is connected together with the feedback. The null junction supports a virtual ground because of its large voltage gain to the output, and is the terminal for which the input offset voltage (E_{io}) and input offset current (I_{io}) are measured. Also called the summing junction. (See Figure 6).

offset current—A d-c current flowing into an amplifier input terminal (null junction) when the input or reference source of current is disconnected. The fixed or *initial* part of the offset current (termed I_{io}) may be adjusted to zero by summing a current of opposing direction. The variations in offset current (ΔI_{io}) can be specified as a function of line, load, time and temperature variations. (See Operational Equation and Figure 8).

offset voltage—A d-c potential remaining across an amplifier's input terminals (from null junction to common) when the output voltage is zero. The fixed or *initial* part of the offset voltage (termed E_{io}) may be adjusted to zero on some models, on others it is fixed with a negative polarity. The variation of the offset voltage (ΔE_{io}) can be specified as a function of line, load, time and temperature variations. (See Operational Equation and Figure 8).

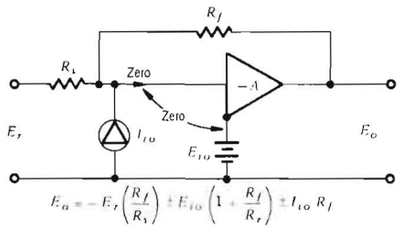


Figure 8—The ideal amplifier (input offsets considered zero) combined with discrete sources representing the actual currents and voltages found in a real amplifier.

open-loop gain — The gain, measured without feedback, is the ratio of the voltage appearing across the output terminal pair to the causative voltage required at the (input) null junction. The open-loop gain is denoted by the Symbol (A) in diagrams and equations. (See Closed-loop *and* Loop Gain).

operational equation–The output (E_o) of a power supply can be related to its input reference (E_r) by an equation which includes the operational gain G. For an inverting amplifier, $G = R_f/R_i$, the ratio of feedback to input resistances.

Omitting the effect of input offsets:

$$E_o = G\,E_r = (R_f/R_i)\,E_r.$$

Including the effect of input offsets:

$$E_o = E_r\,(R_f/R_i) + E_{io}\,(1 + R_f/R_i) + I_{io}R_f.$$

Variations in the output E_o may be determined from knowledge about the reference and offset changes by writing a delta equation

$$\Delta E_o = \Delta E_r\,(R_f/R_i) + \Delta E_{io}\,(1 + R_f/R_i) + \Delta I_{io}\,(R_f)$$

(assuming ΔR_f and ΔR_i are negligible for line, load, time or temperature).

operational power supply—A power supply whose control amplifier has been optimized for signal processing applications rather than the supply of steady-state power to a load. A self-contained combination of operational amplifier, power amplifier and power supplies for higher power operational applications.

operational programming—The process of controlling the output voltage of a regulated power supply by means of signals (which may be voltage, current, resistance or conductance) which are operated on by the power supply in a predetermined fashion. Operations may include algebraic manipulations, multiplication, summing, integration, scaling and differentiation. (See Figure 6).

output impedance—The effective dynamic output impedance of a power supply is derived from the ratio of the measured peak-to-peak change in output voltage to a measured peak-to-peak change in alternating load current. Output impedance is usually specified throughout the frequency range d-c to 100 kc. (See Figure 9).

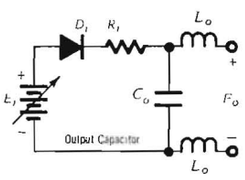


Figure 9—Equivalent circuit for series regulated power supply.

overshoot—A transient rise beyond regulated output limits, occurring when the a-c power input is turned on or off, and for line or load step changes.

parallel operation—The connection of two or more elements or supplies such that corresponding polarity terminals are connected together, and their currents sum in a load.

pass element—An active circuit element used to control the output of a series regulated power supply by varying its conduction. The pass element (commonly a transistor or tube) is arranged between the raw d-c source and the output terminals, controlled by an amplifier to produce a voltage drop across its own terminals.

phase margin—The amount of phase shift, subtracted from 180°, found in a feedback system at the frequency for which its gain reaches unity. The margin from 180° represents the degree of dynamic stability.

phase shift—The time difference between corresponding points of a waveform at different places in a circuit. (Example: input and output). Based on 360° for a single cycle, the time lead or lag is expressed in degrees. An inverting amplifier, for example, ideally exhibits 180° phase shift.

power factor—The ratio of real to reactive power at the a-c line input to an equipment.

power supply (a-c to d-c)—Generally, a device consisting of transformer, rectifier and filter for converting available a-c to a prescribed d-c voltage or current.

programming—The control of any power supply functions, such as output voltage or current, by means of an external or remotely located variable control element. Control elements may be variable resistances, conductances, or variable voltage or current sources. (See Figure 10).

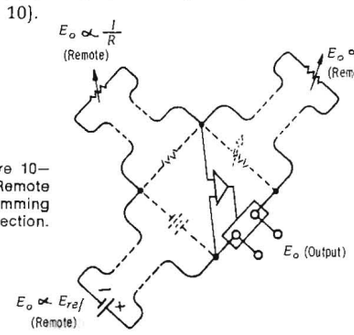


Figure 10—Remote programming connection.

programming ratio—The ratio of command signal to output. For a voltage regulator, resistance controlled, the programming ratio is expressed in ohms per volt, and is a reciprocal function of the power supply's control current, e.g., a 1 mA control current corresponds to 1000 ohms per volt, 10 mA corresponds to 100 ohms per volt.

programming speed—The rate of change of output voltage following a step command measured as the chord of the exponential from the origin to the first time constant. The programming speed also governs the response time of the power supply when it functions as a current regulator. (See Figure 11).

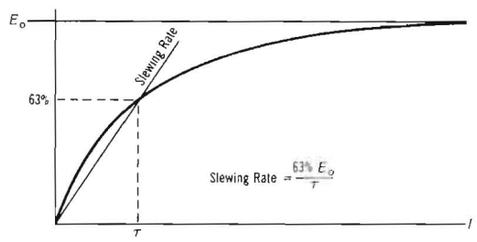


Figure 11—Determination of slewing rate.

recovery time—A measure of the transient response to a step load change, recovery time signifies the time required for the controlled parameter to return to within a specified level. In Kepco power supplies, the specified level is the d-c load regulation specification. Recovery time is used for conventionally filtered voltage regulators to describe the recovery for a step change in load current.

rectifier — A device used to convert an alternating waveform to a direct current (d-c); part of the raw supply in all a-c/d-c power supplies. *Half wave rectifier:* produces d-c from a-c by passing alternate half cycles of the same polarity. *Full wave rectifier:* produces d-c from a-c by reversing alternate half cycles so they are of the same polarity. (See Figure 12a and b).

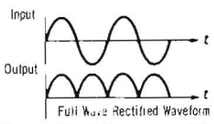


Figure 12a—full wave rectification.

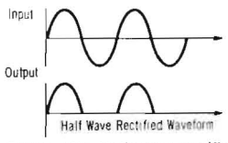


Figure 12b—Half wave rectification.

regulated power supply—An energy converter containing circuits or elements designed to make its output resemble the ideal of either a voltage source (low impedance) or a current source (high impedance). Usually also containing elements intended to make the output insensitive to changes in the source or line.

regulation — *(v)* The process of controlling a parameter (voltage or current) for the purpose of maintaining it constant. *(n)* The amount of *change* observed in the controlled parameter versus the causative variation in line, load, temperature or time. Variations for each cause are usually specified separately.

regulation, line—*(v)* The process of regulating against changes in primary (line) voltage. (n) The amount of output change experienced when the line varies through a prescribed amount.

regulation, load—*(v)* The process of regulating against changes in load. *(n)* The amount of output change experienced when the load varies through prescribed limits.

remote error sensing—A means by which a regulator circuit senses the potential at a remote point (usually the load) and causes the power supply to control *that voltage*. This connection is used to compensate for the voltage drops in connecting wires.

resolution (control) — The minimum increment that can be spanned with a manual control. For continuous elements, the minimum increment is taken to be 1° of shaft rotation.

response time — A measure of the transient response to a step load change, response time signifies the time corresponding to a single time constant on an exponential. Response time is normally used for fast slewing power supplies and current regulators for which other dynamics have been defined in terms of the time constant. (See Figure 13).

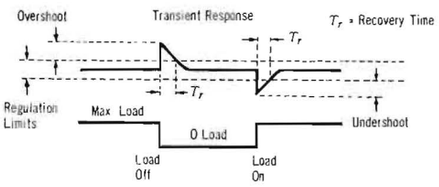


Figure 13—The effects of a step load change.

return supply — An auxiliary source used within a power supply to enable it to operate at zero output. The return supply provides a current path to generate the pass voltage drop for an unloaded supply.

ripple—An unwanted a-c component on the output of a d-c supply. May be composed of line harmonically related components, plus noise induced from other sources.

series operation—The connection of two or more elements or supplies such that alternate polarity terminals are connected together and their voltages sum in a load. Load current is equal and common through each supply. The extent of series connection is limited by the maximum specified potential rating between any output terminal and ground. (See Isolation Voltage). For series connection of current regulators, master/slave (compliance extension) or automatic crossover is used.

series regulator — A form of control employing the active regulating element in series with the output (between the d-c source and the regulated output terminals).

shunt regulator — A form of control employing the active regulating element in shunt (parallel) with the output.

slaved tracking—A system of interconnection of two or more regulated supplies in which one (the master) operates to control the others (the slaves). The output voltages of the slave units may be equal or proportional to the output voltage of the master unit. (The slaved output voltages track the master output voltage in a constant ratio.) (See Complementary Tracking *and* Master/Slave). (See Figure 2).

slewing rate—See Programming Speed.

spoiler resistors—A means of raising the source impedance of a voltage regulator, sufficiently to permit parallel operation, used where other means of parallel operation are not provided.

stability, long term (LTS)—The change in output or offset parameter as a function of time, at constant line voltage, load and ambient temperature (sometimes referred to as drift). Kepco specifies stability as the change experienced per 8-hour period of time.

step line voltage change—An instantaneous change in line voltage (e.g., 105-125V a-c); for measuring line regulation and recovery time.

step load change—An instantaneous change in load current (e.g., zero to full load); for measuring the load regulation and recovery time.

summing point—See Null Junction.

temperature, ambient—The temperature of the environment in which operation takes place. Ambient temperature may be influenced by the dissipation of heat generating equipment in confined areas. For example, the interior of a crowded equipment enclosure may be significantly warmer than outside. However, the local environment of the component equipment, is the *ambient temperature*.

temperature coefficient — A measure of an instrument's response to a variation in its environmental temperature; normally expressed in a percentage of change per degree temperature variation.

temperature, operating—The range of environmental temperatures through which specified operations can be obtained. For power supplies, the temperature is measured exclusive of the heat rise, below the equipment or at the air intake.

temperature, storage — The range of environmental temperatures through which safe storage is possible without deterioration of any physical or operating parameter, and so that the unit will reliably function when returned to a temperature within its operating temperature range.

unipolar—Having but one pole, polarity or direction. Applied to amplifiers or power supplies, it means that the output can vary in only one direction from zero and, therefore, will always contain a d-c component. (See Bipolar).

unity gain bandwidth — A measure of the gain-frequency product of an amplifier. Unity gain bandwidth is the frequency at which the *open-loop gain* becomes unity, based on a 6 db per octave crossing. (See Figure 14), (Typical Gain-Frequency (Bodé) Plot)

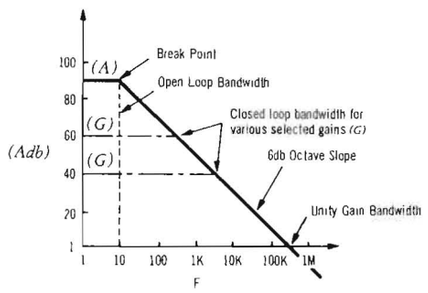


Figure 14—Typical gain-frequency (Bodé) plot.

virtual ground—The condition existing at the input terminals of a high gain voltage amplifier. If this gain is large, the input is small and may be assumed "virtually zero", thus the input terminal is at *virtually* ground potential.

VIX® — A KEPCO designation for a visual/electrical signalling means used in automatic crossover power supplies to indicate the mode of operation—voltage or current.

voltage reference—A source of potential employed as the comparison reference for a power supply. The reference is usually based on a temperature-compensated zener diode energized from a separate regulated source. In the operational sense, the voltage reference forms the *input* to the amplifier.

warmup time — The time (after power turn-on) required for the output voltage, or current, to reach an equilibrium value within the stability specification. The time is typically a function of power supply loading and size and will vary from 15 to 45 minutes.

The modern regulated power supply is a versatile instrument, capable of performing a wide range of signal and power control functions. To get the most from such equipment, a clear understanding of the fundamentals is essential. These notes seek to provide a basis for this understanding, using Kepco's operational notation as the basis for describing power supply performance.

For an expanded treatment of the subject, the Kepco Power Supply Handbook *can be obtained by writing to the* Publications Manager, *Kepco, Inc., 131-38 Sanford Avenue, Flushing, N.Y. 11352. Additional text material is listed in the bibliography.*

GENERAL

Power supplies, as manufactured by Kepco, have two fundamental tasks, "*regulating*" (or the maintaining constant) of voltages and currents, or *control*, meaning the ability to adjust – or modulate the output voltages and currents. These two seemingly opposite tasks are performed by the same feedback circuit in essentially the same way, and may even occur simultaneously. For example, voltage may be *regulated* against primary (AC) power variations yet *controlled* (varied) by an external modulating signal. As a matter of convenience, somewhat different language is used to describe the behavior of a power supply when it is asked to *regulate* than when it is called upon to *control*. But because they depend on the same physical circuits, it is possible to translate easily from one set of terms to another. Users will find it convenient to use whichever language best fits the circumstances at hand.

Those power supplies which by their design are especially suited for *control* purposes are termed "operationally programmable," and have their performance specified two ways. In terms of their *regulator* performance (as a power supply) and in terms of their control ability (as if they were DC amplifiers). Indeed, viewed operationally, programmable power supplies do resemble unipolar, high power DC inverting amplifiers, and the language used to describe their performance is similar to the operational amplifier lexicon.

The Kepco "OPS" series power supplies carry the amplifier identification one step further by substituting amplifier-type controls (gain, offset, patch panels, etc.) for power supply controls, meters, voltage/current adjustments, etc. These models are identified by their "OPS" prefix.

This catalog also lists power supplies with a unique fast-slewing ability. That is, their outputs can be commanded to change quickly from one value to another. Such supplies are offered in several forms:

- Convertible (high-speed/normal-speed): BHK Models
- High-speed conventional form: CK-HS and PAX-HS
- OPS form: OPS Models

The paragraphs that follow detail these special characteristics.

THE POWER SUPPLY—AMPLIFIER ANALOG

In terms of its ability to control voltage or current, a power supply may be viewed as a special form of operational amplifier. That is, it has an "input" or null junction, an output, and a terminal common between them. The amplifier used in a power supply's regulator exhibits from 80 to 120 db of open-loop gain so that with feedback, the simplifying assumptions of operational analysis may be applied.

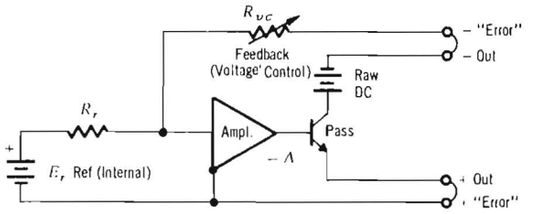


Figure 1—Power supply shown explicitly with reference, amplifier, raw d-c and series pass.

Drawing the power supply symbolically as an amplifier, the terminals corresponding to input/output and common are easily identified. In fact, it is not really necessary to show the amplifier and pass elements and raw DC supply as separate elements, if we are merely interested in their external behavior, the simplified diagram of Figure 2 may be substituted.

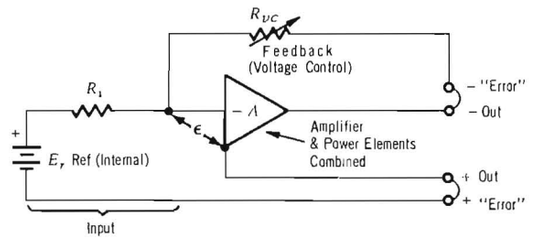


Figure 2—Power supply drawn more simply as an inverting d-c amplifier showing the reference as input.

Assuming large gain A, the amount of signal ϵ required to produce E_o, the output, is small. If ϵ is sufficiently small, it can be considered zero for the purposes of this analysis, and the equation of balance becomes:

$E_r/R_1 = E_o/R_f$

from which we derive the familiar inverting amplifier's gain expression:

$E_o = (R_f/R_1)\, E_r$. . *where* $R_f/R_1 = G$, the gain.

The use of the analog model enables a designer to visualize the effects of various control modes and their interrelationships. For example, the conventional power supply voltage control adjustment (R_f) is seen to operate the equipment as a variable gain amplifier with a fixed input (called the reference). Or, fixing R_f and R_1, a variable voltage may be substituted for the reference to drive a fixed gain amplifier. This we call programming by external voltage.

If R_1 is varied instead of E_r or R_f, inverse programming results because R_1 is in the denominator of the equation:

$E_o = E_r\, (R_f/R_1)$

As an inverting amplifier, the input is applied through R^1 to a terminal pair supporting a null. The input impedance is, therefore, R_1. A power supply may, however, be driven between the output and null junction, in which case it becomes a noninverting amplifier with high input impedance and unity gain, a "voltage follower" or "impedance transformer." (See Figure 3).

Because of the power supply's ability to successfully emulate its operational model, there are many jobs which may be undertaken by *operational power supplies* which

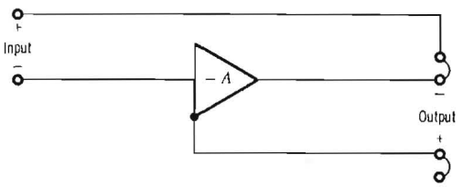


Figure 3–Power supply/amplifier drawn as a non-inverting unity gain follower with high input impedance.

combine the characteristics of an amplifier (high gain, fast slewing, low offset) with the advantages of a power supply (high power, self-contained sources, self-regulating).

OFFSET RATINGS

The operationally programmable and OPS model Kepco Power Supplies are extraordinarily versatile in their application to complex control problems. No longer are the traditional line and load regulation specifications sufficient to define the performance.

Kepco has adopted the *input referred offset* form of specification writing for these units to obtain a more generalized form of rating, one that is independent of the associated input and feedback elements. For convenience, the offsets are divided into two parts, offset voltage and offset current. They are specified separately as variables for line, load, temperature and time changes. The offset voltage and offset current also have a fixed or initial part which does not contribute to an output *change*, and can be adjusted at will, or nulled, as desired.

In this catalog, the symbol E_{io} is used to represent the input offset voltage, and ΔE_{io} its variable part. I_{io} is the input offset current and ΔI_{io} is the variable part.

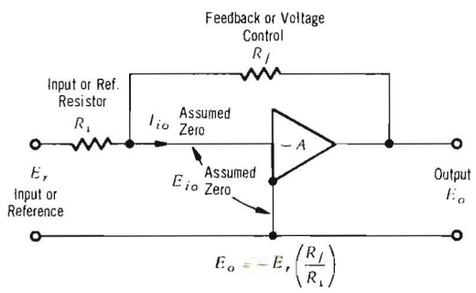


Figure 4–With assumed ideal input offset conditions, $E_o = -E_r\ (R_f/R_1)$.

These parameters may be visualized as separate sources in conjunction with an ideal amplifier (the power supply). In *Figure 4*, the ideal amplifier representing a power supply is illustrated. *Figure 5* shows the explicit nonidealities of E_{io} and I_{io} added to the amplifier's diagram.

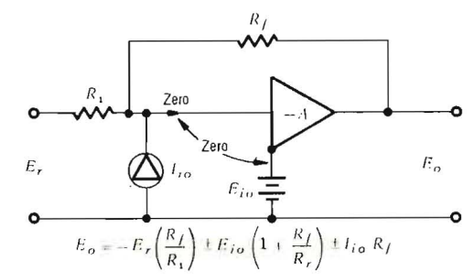


Figure 5–The ideal amplifier (input offsets considered zero) combined with discrete sources representing the actual currents and voltages found in a real amplifier.

The expression that relates the offset voltage (or its variation ΔE_{io}) to the output is:

(1) $\Delta E_o = \Delta E_{io}\ (1 + R_f/R_1)$

The offset current (variations) contribute:

(2) $\Delta E_o = \Delta I_{io}\ (R_f)$

These two effects, together with the reference variations:

(3) $\Delta E_o = \Delta E_{ref}\ (R_f/R_1)$

constitute the complete equation for a power supply's variations.

(4) $\Delta E_o = \Delta E_{ref}\ (R_f/R_1) + \Delta E_{io}\ (1 + R_f/R_1) + \Delta I_{io}\ (R_f)$.

To compute the effect of a particular parameter change (line, load, temperature or time) on the output of the amplifier/power supply, it is only necessary to know the input and feedback impedance, and the reference.

REMOTE ERROR SENSING:

Precision voltage regulators with substantial current ratings are always equipped with error-sensing terminals that are separate from the output terminals. The sensing terminals correspond to the common point and feedback point, respectively, and are the terminals across which the power supply actually controls its voltage. To regulate voltage at any point remote from the power supply, separate wires should be run from the respective sensing terminals to the desired sensing point. The power supply will thereupon regulate or control the voltage at that point. There is provision for as much as 0.5V drop per output power lead in Kepco power supply designs. For a change in load current, the output terminal voltage will alter automatically to compensate for this much line loss to regulate the remote sensing point.

To preserve the step-load current transient response (recovery time), a power supply's output filter-capacitor is not connected to the output terminals (where it would have to charge and discharge as the output compensated for a varying line drop). Instead, the filter is connected directly to the error-sensing terminals where it limits the transient excursion by acting as a local energy source during the recovery interval.

There is a special diode connected across each error-sensing link (to the respective output terminal), whose function is to conduct should the connections be inadvertently omitted. These diodes prevent an uncontrolled response when the links are open and a remote connection is missing.

In laboratory supplies, the output and error-sensing wires are routed first to the front panel terminals and thence to the output/sensing pair normally located at the rear. This has the effect of being an automatic sensing selector placing the sensing point effectively at whichever output terminal pair (front or rear) happens to be in use.

DYNAMICS

The time and frequency domain characteristics of a power supply are specified in terms of its response to a step or sinusoidal variation of either voltage or current.

As a *voltage* regulator, *load* variations manifest themselves as a change in current. In the time domain (step response), the dynamics are usually expressed as a "response time" or "recovery time"; while in the frequency domain, the dynamics are expressed in a plot of the output impedance vs. frequency.

As a current regulator, *load* variations manifest themselves as a change in the compliance voltage. The rate of change of the compliance voltage, the voltage slewing rate, governs the time response (recovery) and frequency characteristic (output impedance). For conventionally filtered equipment, it is functionally dependent on the ratio of the output current limit to ouput capacitance:

$$\Delta V/\Delta T = I_o/C_o$$

This will vary widely, having a mean value of a few hundred volts per second for most supplies. Because the slewing rate, $\Delta V/\Delta T$, varies as a function of the current limit setting, and as a function of the value of an electrolytic capacitor, it is usually not specified for a conventional power supply.

High speed power supplies, operational power supplies (OPS) and models offering normal/high-speed convertibility have much faster slewing rate abilities, ranging from 50,000 to 1,000,000 volts per second. For these models, a response time for step load variations in current mode can be specified in terms of volts per microsecond. A 100,000 volt per second slewing rate means 0.1 volt per microsecond transient response as a current regulator.

Because the slewing rate is defined as the slope to the first time constant (63%), the *response* time rather than *recovery* time is used to describe the transient behavior of a current regulator. Response time refers to 63% recovery, while recovery time usually refers to a specific level—the DC load regulation level for all Kepco voltage regulators.

The slewing rate of a power supply also governs the sinusoidal bandwidth that the circuit will pass, undistorted, as a linear function of amplitude. Figure 27 plots several slewing rates vs. peak-to-peak sinusoidal amplitude to help determine the maximum frequency. For example, a model having (a programming speed of 500,000V/sec.) and programmed (commanded) to produce a 10V peak-to-peak output sinusoid will have a 16 kc. band pass.

Output Impedance

As the time domain expression of a power supply's dynamics, the output impedance represents the "dynamic regulation" and is usually measured and specified.

For a voltage regulator, the output impedance (Z_o) is the incremental impedance obtained by varying the load current I_o and observing the small resulting voltage swing E_o:

$$Z_o = \Delta E_o/\Delta I_o$$

Z_o is ordinarily expressed as a function of frequency. Of primary importance, however, is not the *magnitude* of the impedance at any arbitrary frequency, but rather the shape of the plot Z_o vs. frequency.

Above 10 to 20 kc, the impedance is mostly reactive (inductive) and can be specified by stating the equivalent inductance in microhenries. From the reactance chart, a 1 microhenry inductance is about 0.6 ohms at 100 kc. Connecting wires also contribute a series inductance, usually substantially larger than the equivalent inductance of the supply itself and should be accounted for when estimating the high frequency impedance presented by the supply and its wires to a load.

Plotted vs. log frequency, the impedance should show a smooth curve similar to Figure 6. Any peaks or pronounced dips, particularly in the region of the breakpoint near 1 to 10 kc, indicate a misadjustment of the AC stability controls (lag networks) or a marginal output filter-capacitor.

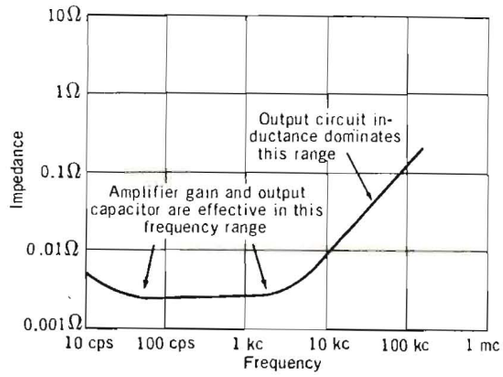


Figure 6—Typical power supply output impedance plot on log-log paper.

Since many load circuits depend upon the decoupling effect of a power supply's low source impedance, the following procedures are recommended to minimize the effect of wiring inductance: load wires should be twisted together and should be of the heaviest possible gauge. Remote error sensing wires should be twisted together, and, in addition, a capacitor bypass *directly at the load terminals* is very useful. Such a capacitor acts at a local energy source, compensating for the load wiring inductance. When particularly long sensing leads are used, it is sometimes helpful to connect local sensing bypass capacitors *at the power supply*. These would be placed between the individual plus and minus output terminal and their respective error sensing terminal. They serve to bypass the combination of load-wire and sense-wire inductance and prevent transient instability.

CURRENT REGULATION

Power supplies regulate current by controlling the voltage drop across a sensing resistance placed in series with the load. By regulating the voltage across a fixed resistor, the current through it, and the load, is regulated.

The features chart on Page 2 lists models designated as "automatic crossover" designs. This means that a current sensing circuit, with a built-in sampling resistor, amplifier, and gate, is included as part of the supply. Such supplies have two independent sensing and control circuits; one for voltage, the other for current.

Other models, designated as being suitable for "current regulation"— but not automatic crossover designs—have a single sensing and control amplifier which is normally used to sense voltage. In these designs, access terminals are provided, together with instructions for conversion to current sensing and control using the external components.

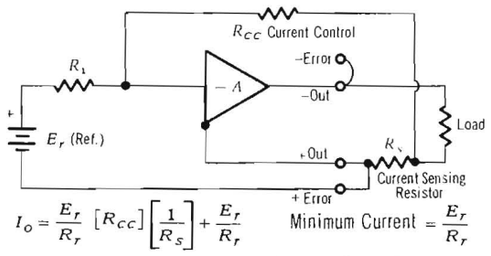


Figure 7—Current regulating configuration.

For most models, a minimum current level is specified. Special techniques can be employed to alter and even eliminate this minimum level. Please refer to Chapter 4, *Current Regulation*, in the *Kepco Power Supply Handbook*.

AUTOMATIC CROSSOVER

Power supplies featuring the twin regulator circuit, for voltage and current, have what is known as an automatic crossover output characteristic. Such power supplies operate either as voltage regulators or current regulators, crossing over automatically, from one mode to the other as determined by the voltage and current level settings, and the load resistance.

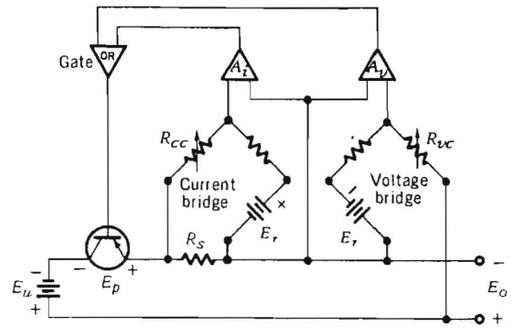


Figure 8—Kepco twin-bridge automatic crossover circuit.

On the *E/I* plane, the locus of a voltage regulator is a horizontal line, adjustable vertically. The locus of a current regulator is a vertical line, adjustable horizontally. Their intersection, for any given pair of adjustments, is the crossover point. A power supply with these adjustments operates at a point determined by the intersection of the locus lines with a radial load line representing a resistance.

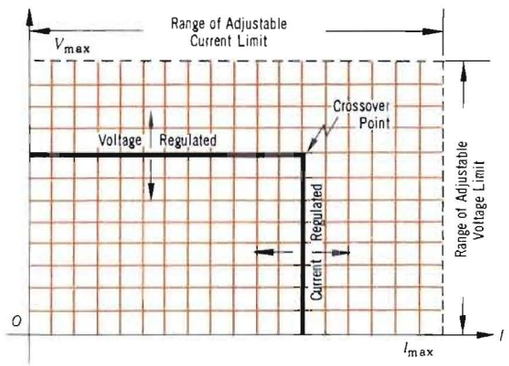


Figure 9—Typical characteristic automatic voltage/current crossover.

Power supplies equipped to operate this way are self-determining, able to drive any load from zero to infinity without difficulty, and incapable of overload.

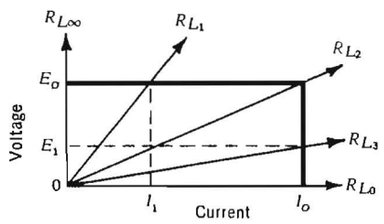


Figure 10—The locus of a variable load resistance is a plane corresponding to the first quadrant. An infinite resistance (open circuit) corresponds to the voltage (vertical) axis. A zero resistance (short circuit) corresponds to the current (horizontal) axis. Resistors from 0 to ∞ span the first quadrant.

Automatic crossover power supplies operate equally well as voltage and current regulators. They are provided with two controls for the purpose of setting levels. Kepco reserves the use of the term "automatic crossover" to those supplies in which the internal current regulator is comparable to the voltage regulator.

If immunity to overload is the prime objective, then a less sophisticated sort of circuit might be chosen. This is called current *limiting*, which provides a locus similar to that of an automatic crossover supply, but lacking the sharp precision in current mode that characterizes a true current regulator.

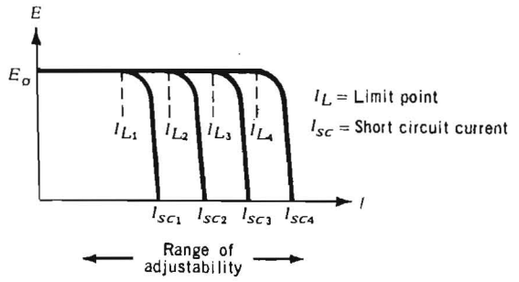


Figure 11—Current limiting curves. Note that I_{sc} is always greater than the current at which limiting begins, I_L.

Current limited power supplies are intended for operation only along the horizontal (voltage mode) part of its output locus. The vertical part serves only to prevent overload damage.

VIX®

As a convenience, some automatic crossover models are equipped with a pair of indicator lights, and an output signal jack, to signal the mode of the equipment. The VIX (Voltage/Current Crossover) circuit is connected to the power supply's decision gate, and by lighting one lamp or the other, enables a user to know the mode chosen by his power supply equipment. There is a ±8V DC signal, isolated, whose polarity reverses at crossover and which may be used to activate alarm signal devices or automatic machinery. An accessory, Model VIX-1C operates on 3PDT, 115V AC, 10A relay at crossover to power external apparatus. BHK models provide a relay contact closure directly as an external VIX signal.

CURRENT CUTOFF:

The Kepco PWR and PAR designs employ a current cutoff form of overload protection in which both voltage and

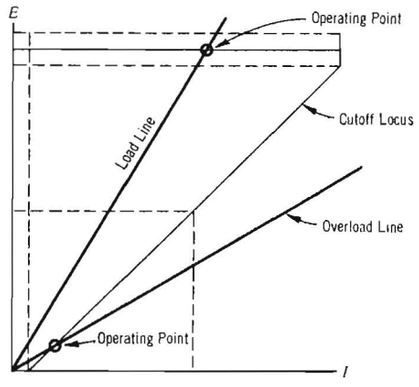


Figure 12—Overload protective mechanism of current cutoff circuit.

current diminish simultaneously when the load exceeds the limit setting plotted on the *E/I* plane. The cut off locus has a form of Figure 12. Operation occurs at the intersection of the radial load line with the operating characteristic. As the load resistor is made smaller, the load line rotates clockwise. At the limit point, it can be seen that the operating point migrates rapidly back toward the origin. This design allows for some degree of remote programmability with the proviso that the current rating derates linearly with voltage setting, i.e., at half voltage, approximately half current can be drawn.

FLUX-O-TRAN®

Kepco's PR, PRM, SM and PWR Power Supplies use a special regulating power transformer that operates on the flux-oscillating, resonant tank principle.

Briefly, the Flux-O-Tran secondary is wound on a separate magnetic structure, separated from the primary by a special magnetic shunt. It is connected to a tank capacitor to form a resonant circuit at the line frequency. When excited, the resonant circuit builds up sufficient flux to saturate the iron core on each half-cycle.

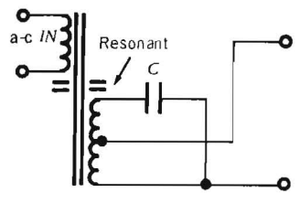


Figure 13—
Kepco Flux-O-Tran.

For a constant frequency, the capacitor voltage is constant and is essentially independent of the input amplitude, provided that the input is large enough to sustain oscillation.

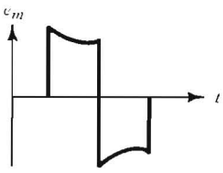


Figure 14—
Output waveform
from Flux-O-Tran.

The output waveform is as shown in Figure 14, having a generally rectangular shape which, when rectified, offers a lower peak-to-average ratio for better load regulation and smaller ripple. Power supplies employing the Flux-O-Tran have the advantage of line regulation, line isolation (transients and spikes do not get through a Flux-O-Tran), load regulation, low ripple, and overload protection, (when shorted, the (Q) of the resonant tank won't support oscillation), all within a very simple, extremely reliable transformer design.

HYBRID DESIGN

High voltage power supplies in the Kepco HB, BHK, and ABC design classifications employ a unique combination of solid state reference and amplifier circuits with rugged, high voltage series pass tubes to regulate the high voltage. These designs are used from 200V DC to 2500V DC in power ratings from 20 watts to 200 watts.

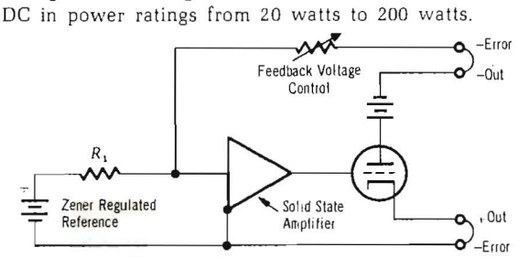


Figure 15—Kepco hybrid design.

SERIES AND PARALLEL:

Voltage regulators are easily connected in series, and current regulators are easily paralleled. On some supplies, special provisions are made for paralleling voltage regulators, and most current regulators have provision for series compliance extension. Automatic crossover supplies, since they are free to choose their mode automatically, may be series or parallel connected without concern.

However the arrangement for interconnecting power supplies in series or parallel, an isolating diode is recommended to prevent damage to one supply by another.

For parallel current regulators, this takes the form of a diode in series with each source.

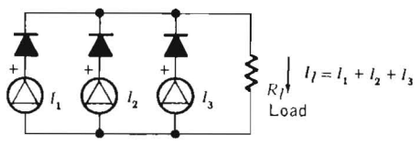


Figure 16—Diodes protect parallel current regulators.

For series voltage regulators, a shunt diode across each power supply is the recommended precaution.

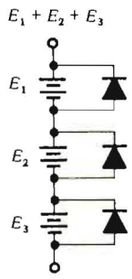


Figure 17—Reverse diodes protect a series string of voltage regulators.

MEASUREMENTS:

The following circuits and techniques can be employed to verify power supply performance characteristics. Depending on the type of power supply, measurements may be made for voltage regulation vs. primary power (line), current (load), environment (temperature) and time (stability). Similar measurements are also performed for current regulation in those supplies possessing two control amplifiers (automatic crossover power supplies).

Operationally programmable power supplies may also be measured for their offset referred to the null junction, and high speed models will require dynamic testing in the time domain to verify slewing rates. Additionally, measurements of output impedance and recovery time may be performed for a comprehensive test.

When measuring *any* parameter for a voltage-controlling power supply, observe good four-terminal network practices. Do not permit any series current-carrying impedance to intrude in the voltage-measuring path. In practice, this may be assured by connecting all measuring apparatus directly to the power supply's error-sensing terminals with *everything* else (loads, etc.) to the *output* terminals. Of course, to drive a real load with equivalent performance, the remote-sensing connection would be used to compensate for the inevitable series resistance of the load-connecting wires.

Current regulators require the precaution of eliminating shunt conductance paths if accurate results are to be obtained. The most obvious example of a shunt conductance is a voltmeter or similar instrument, which may remain connected after the voltage-measuring procedures are completed. Current regulation is usually evaluated by inserting a sensing resistor in the current flow path, and proceeding to monitor its voltage drop as a measure of the current. In general, a separate resistor should be used for this purpose, not the same resistor that the power supply employs for its own current sensing. The sensitivity of measurement will depend on the size of the sample, with larger voltages yielding greater sensitivity. The limit in this regard is simply the amount of voltage compliance range that can be devoted to the measuring resistor rather than the load.

Ripple, measured in either voltage or current modes, should be expressed in the correct units for the mode. Current ripple in amperes; voltage ripple in volts. Specifications are written in terms of rms volts, but observations of the peak-to-peak ripple should also be made to insure that the ratio not exceed 3:1 to 5:1. The oscilloscope monitor should also be used to ascertain that there are no nonharmonic frequency components, particularly at high frequencies, and that there is not an excessive 60-cycle component (indicative of pickup/grounding problems in the measurements setup).

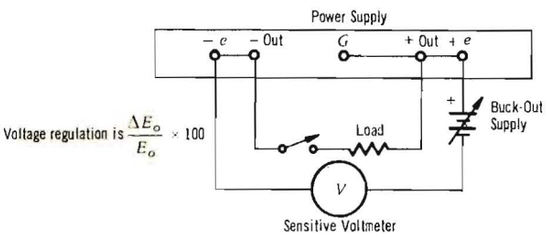


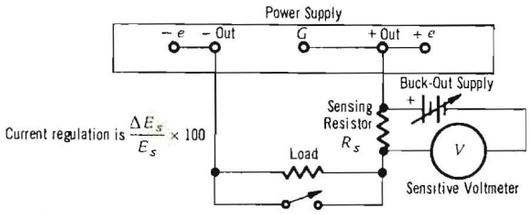
Figure 18—Basic voltage measuring circuit.

LOAD REGULATION:

Vary the load voltage or current in a step fashion and observe the resulting change in the measured parameter *at its sensing terminals*. For voltage load regulation, measure at the power supply's error-sensing terminals; for current load regulation, measure at the signal terminals of the current-sensing resistor. To express regulation as a percentage, divide the observed change by the output setting or sample magnitude and multiply by 100. A measurement at small output settings will, in general, yield a higher percentage figure as the *minimum* error *magnitude* is encountered. For a voltage regulator, in the limit, as the output *voltage* setting is made zero using the feedback voltage control, the *minimum* error *magnitude* becomes equal to the offset voltage variation ΔE_{io} for load.

LINE REGULATION:

To measure line regulation, vary the primary power to the supply through the rated limits while observing the corresponding change in output voltage or current at their respective sensing points. To obtain the percentage, divide by the magnitude of the output — or the sample — and multiply by 100. Be certain that the means used to vary the primary voltage is capable of withstanding the load imposed by the power supply and measure the AC voltage *at the AC terminals* or line cord of the supply to avoid including the line drop in the calculations.



Ground whichever polarity is common to the measuring instruments and bucking supply. Use twisted shielded wiring to minimize pick-up.

Figure 19—Basic current measuring circuit.

TEMPERATURE COEFFICIENT:

Measurements of the coefficient of change for output voltage and output current may be obtained by subjecting the equipment to a known temperature excursion while monitoring the output. All measuring apparatus and comparison sources should, of course, be maintained at constant temperature for the duration of the test. Tests may be made over any temperature range within the power supply's rating, with a minimum span of 10°C recommended. Typically, the range from room temperature 30°C, to 50°C or 60°C might be chosen.

STABILITY:

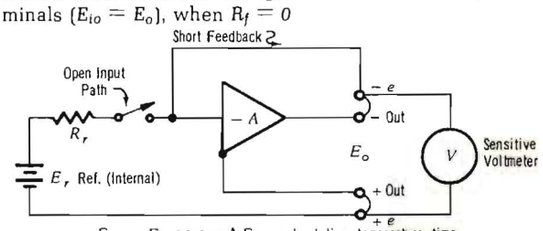
When line variation, load and temperature have been accounted for, residual long-term output variations are classified as "drift" and are specified as the "stability" of the power supply. The usual period of measurement is (8) hours, and the technique is to measure for several consecutive 8-hour periods to obtain significant data. A 16-hour test is standard.

It should be recognized that long-term stability is difficult to define as to magnitude and direction, for to assume that a given rate of drift continues unchanged for all time is to assume that a constantly operating power supply would ultimately saturate, or cutoff. This, of course, does not happen. The output variations are confined to a narrow range and aperiodically reverse direction. Thus, over a sufficiently long time, the drift per unit time should approach zero.

A valid stability measurement requires that line voltage, loading and temperature all remain substantially constant for the duration of the test. Of these requirements, the need for a constant environmental temperature is probably most difficult to achieve. If temperature coefficient is to contribute no more than 10% error to the stability measurement, then temperature must be maintained to within 0.1°C throughout the test.

OFFSET VOLTAGE: (E_{io})

Offset voltage (E_{io}) can be measured with respect to the power supply's voltage amplifier's null junction by eliminating the contribution of offset current. This is done by reducing the feedback resistor (voltage control) to zero. The output voltage will thus be close to zero. Fixed offset supplies should exhibit a polarity reversal (negative offset), while operational supplies with adjustable offset controls, have means for adjustment plus and minus around zero. E_{io} is the voltage measured at the output terminals ($E_{io} = E_o$), when $R_f = 0$



$E_{io} = E_o$, measure ΔE_{io} vs. load, line, temperature, time.

Figure 20—Measuring circuit for voltage offset, E_{io}.

To measure E_{lo} vs. load with the output at zero, will require an auxiliary power source to pass current through the output loop — to overcome the ohmic loss in the circuit wires. Alternatively, the feedback resistor (voltage control) can be set to produce a small output voltage, sufficient to pass the rated current in a load. This procedure adds the effect of internal reference voltage variation and. I_{lo} changes to the E_{lo} measurement, but if the output voltage is kept small, the errors are negligible and can be ignored.

For line variation effects, temperature coefficient and stability measurements monitor ΔE_{io} as the respective parameter is varied through known limits.

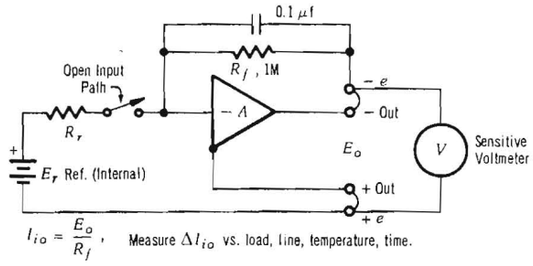


Figure 21—Measuring circuit for current offset, I_{lo}.

OFFSET CURRENT: (I_{io})

I_{io} is measured by monitoring the output voltage when the reference source of control current is disconnected. Because there is no way to eliminate E_{io} from the output of a power supply, I_{io} is isolated for the purpose of measusement by making its effect very large with respect to other contributions. This is done by disconnecting the power supply's reference (E_r) and substituting for R_f a large resistance in the feedback path. Resistances of 100K to 1 meg are commonly used, together with capacitors of between 0.1 and 1 microfarad (C_f), to minimize ripple interference with the measurement:

($I_{io} = E_o/R_f$)

with $R_f = 1$ megohm; 1 mV at the output (E_o) corresponds to 1 nanoampere I_{io}.

For line, load, temperature and time variations of I_{io}, measurements are made by observing the output while selectively varying the respective parameters, as in the previous procedures.

OUTPUT IMPEDANCE:

Voltage load regulation can be expressed as the change of output voltage for a given change in load current ($\Delta E/\Delta I$); it can be seen to have the units of an impedance. A plot of this impedance vs. frequency of load change will define the dynamic regulation of a power supply. To measure impedance vs. frequency, a means of sinusoidally modulating a load is required. Since the impedance is a ratio, the amount of modulation required is not great.

Figure 23 illustrates one way to accomplish load modulation using a power amplifier in parallel with a fixed load resistor. $Z_o = \Delta E_o/\Delta I_o$

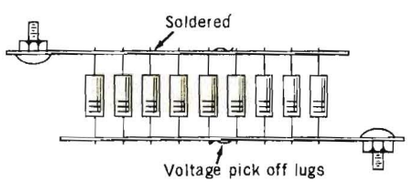
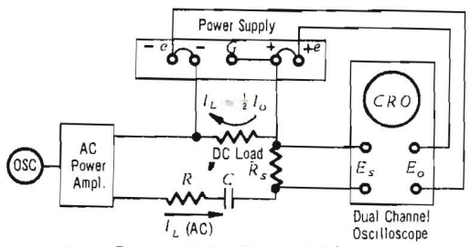


Figure 22—Minimum inductance construction for a sensing resistor to measure a-c impedance.



Measure E_s to compute the AC component of I_L

Z_o, the output impedance $= E_o / I_L$ (AC components)

Figure 23—Measuring circuit for output impedance and transient response.

Choose R to be a proper impedance match for the amplifier; (use the lowest impedance tap) and select C for a 2ms time constant (5% droop in a 100 μs, for transient response testing). The capacitor C must be capable of passing the a-c load current I_L.

Resistor R_s should be non-inductive to avoid erroneous readings at high frequencies. A suggested construction method is to solder 27, 2.7Ω 1 watt carbon resistors between two strips of tinned copper, $R_s = 0.1$. (See Figure 22.

Measurements from DC (load regulation) to 100 kc are typically made. Above 10 kc, the impedance plot should approach the pure reactance of a small inductor. Indeed, the value of the equivalent source inductance is given in the specification. Since the load wires themselves contribute significant inductance, the magnitude of the output impedance at any given frequency is not particularly meaningful. Of greater importance is the shape of the plot vs. frequency, which should look like Figure 6, with no significant humps, dips, etc. The presence of such irregularities would signify potential AC instability and a tendency to oscillation.

RECOVERY TIME:

Recovery time may be measured with the same equipment setup as is used for output impedance. The difference is that the load is square wave modulated, not sinusoidally.

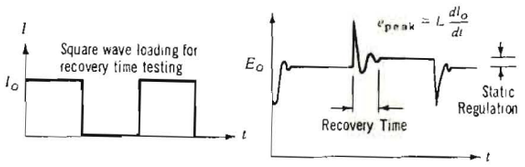


Figure 24—Transient recovery waveform for square wave loading.

Recovery time is preferably defined as the time required for the output to settle back to a specified level. For Kepco, this level is the load regulation band. Response time is used for transient measurements in current mode, and refers to the 63% exponential time constant.

The amplitude of a voltage excursion for a step current change may be computed for a given power supply by the expression $E = L\ di/dt$, where di/dt is the step of current and L is the power supply's specified inductance.

SLEWING RATE:

The programming speed for fast-slewing power supplies is measured by programming with a repetitive step waveform (square wave) while observing the time for the first time constant (63% of completion). The chord from the origin to the 63% E_o time, is given as the slewing rate in volts per second. Slewing rate, or programming speed, governs the response time of a current regulator which is usually expressed in volts per unit time. Fast-slewing power supplies, therefore, have much quicker response as current regulators than conventional speed equipment.

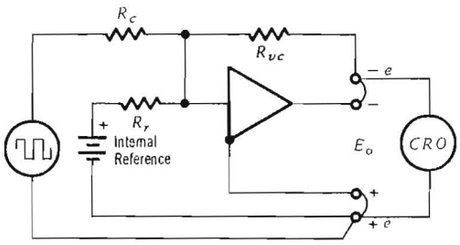


Figure 25—Slewing rate test circuit. Power supply drawn operationally.

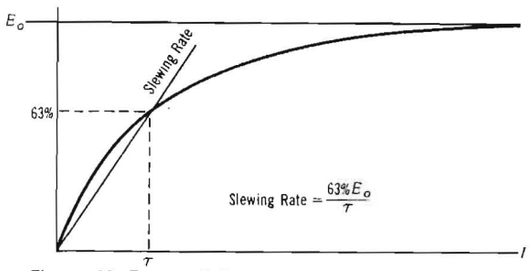


Figure 26—Exponential response to a step program showing method of measuring slew rate.

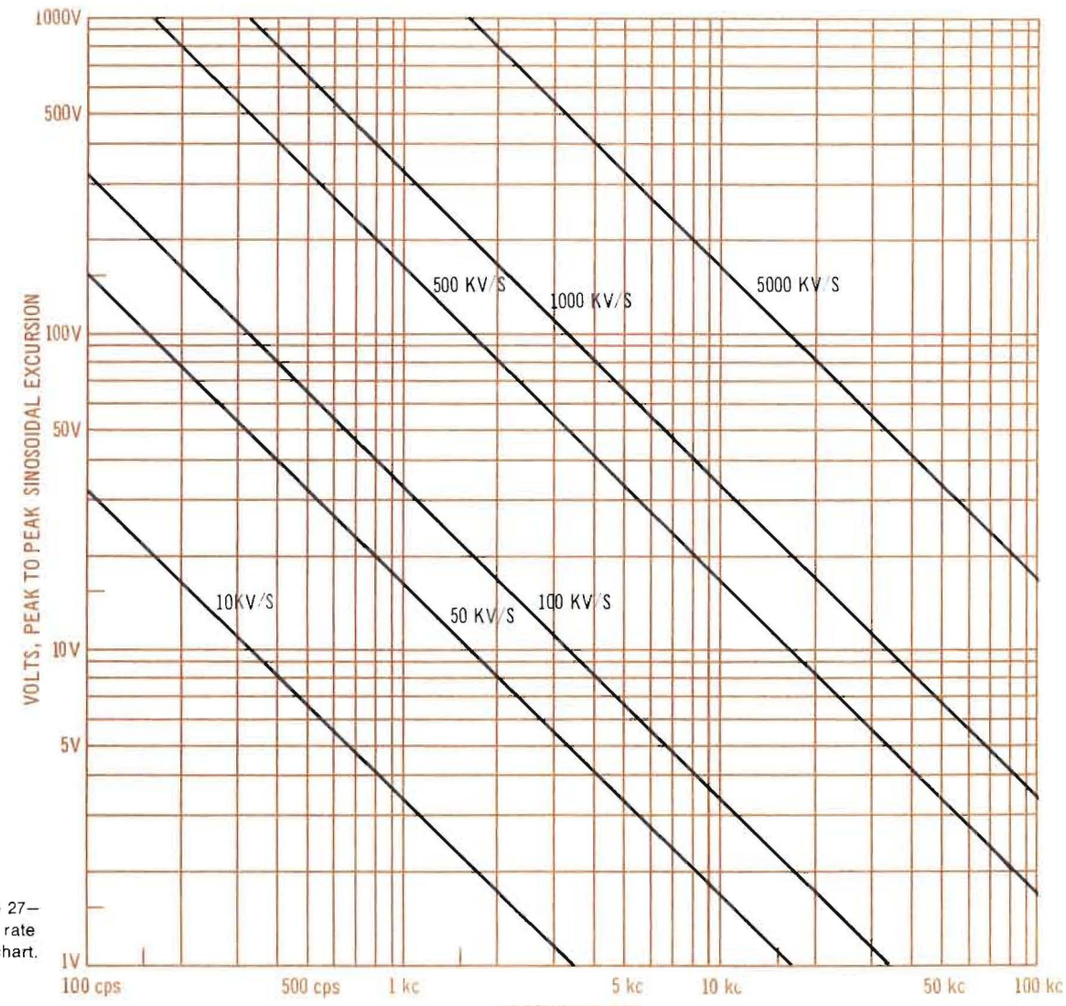


Figure 27—Slewing rate chart.

SLEWING RATE CHART

Slope limited power supplies have their sinusoidal bandwidth limited by the product of frequency (f) and the peak-to-peak signal amplitude (E_{pp}) in the equation:

$$\text{Slewing rate} = \pi f E_{pp}$$

The chart above, plots E_{pp} vs. (f) for several values of the slewing rate from 10,000 volts per second to 5,000,000 volts per second.

These speeds are typical of the Kepco OPS, or high speed power supplies. Such supplies are designed either without an output filter-capacitor, or with a removable capacitor for convertible high-speed/slow-speed operation.

When the capacitor is eliminated in a power supply, its programming speed is greatly enhanced, as is its recovery time as a current source. On the other hand, its margin of AC stability is considerably reduced, necessitating the use of special phase-adjusting circuits to stabilize the feedback. Lacking the field phase relationship imposed by a large output capacitor, stable operation demands that the power supply see a purely resistive load, or a maximum capacitance of 0.001 microfarad.

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Vacuum Tube and Semiconductor Amplifiers – Milman.

NOMOGRAPH OF VOLTAGE DROP ACROSS LOAD SUPPLY LEADS
(as a function of wire size and load current)

THIS NOMOGRAPH CAN BE USED TO FIND:

Maximum current carrying capacity recommended for any standard wire size.*

1) With a straight edge, connect from the wire size on Scale 2 to the point "A" on Scale 3.
2) Read I_{max} on Scale 1.

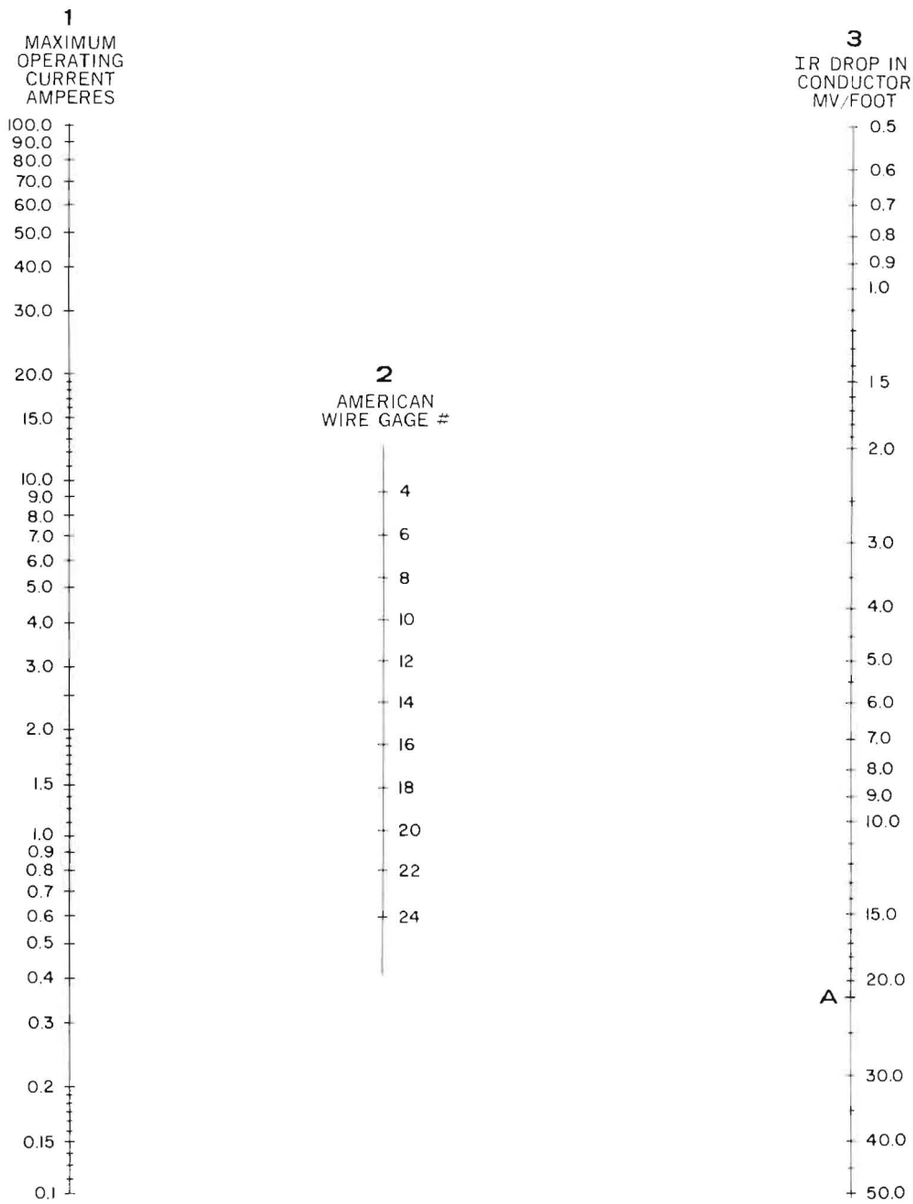
Voltage drop in millivolts per foot for known wire size and operating current.

1) With a straight edge, connect the known current on Scale 1 and the wire size on Scale 2.
2) Read voltage drop on Scale 3.

Wire size required for known operating current and known maximum tolerable voltage drop across supply leads.

1) Determine maximum tolerable drop in millivolts **per foot** of lead (sum of positive and negative leads).
2) Connect the value on Scale 3 (as determined in step 1) to the known current on Scale 1.
3) Read wire size on Scale 2.

*Based on an arbitrary minimum 500 circular mils per ampere. High-temperature class insulation will safely allow higher currents.



NOTE: A voltage regulated Power Supply controls the voltage across its output terminals. Hence the wire conductors used to connect the load must be considered as part of the load. At high load currents the voltage drop across the supply leads may appreciably degrade regulation at the load. Kepco models equipped with the **remote error sensing** feature can automatically compensate for voltage drops of up to 500 mv across each load supply lead.

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